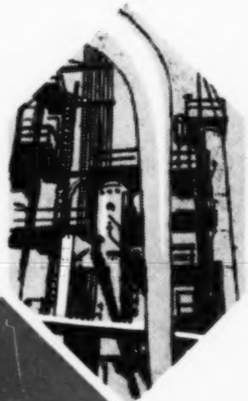
Chemical Engineering Progress

NOVEMBER 1953

exposition



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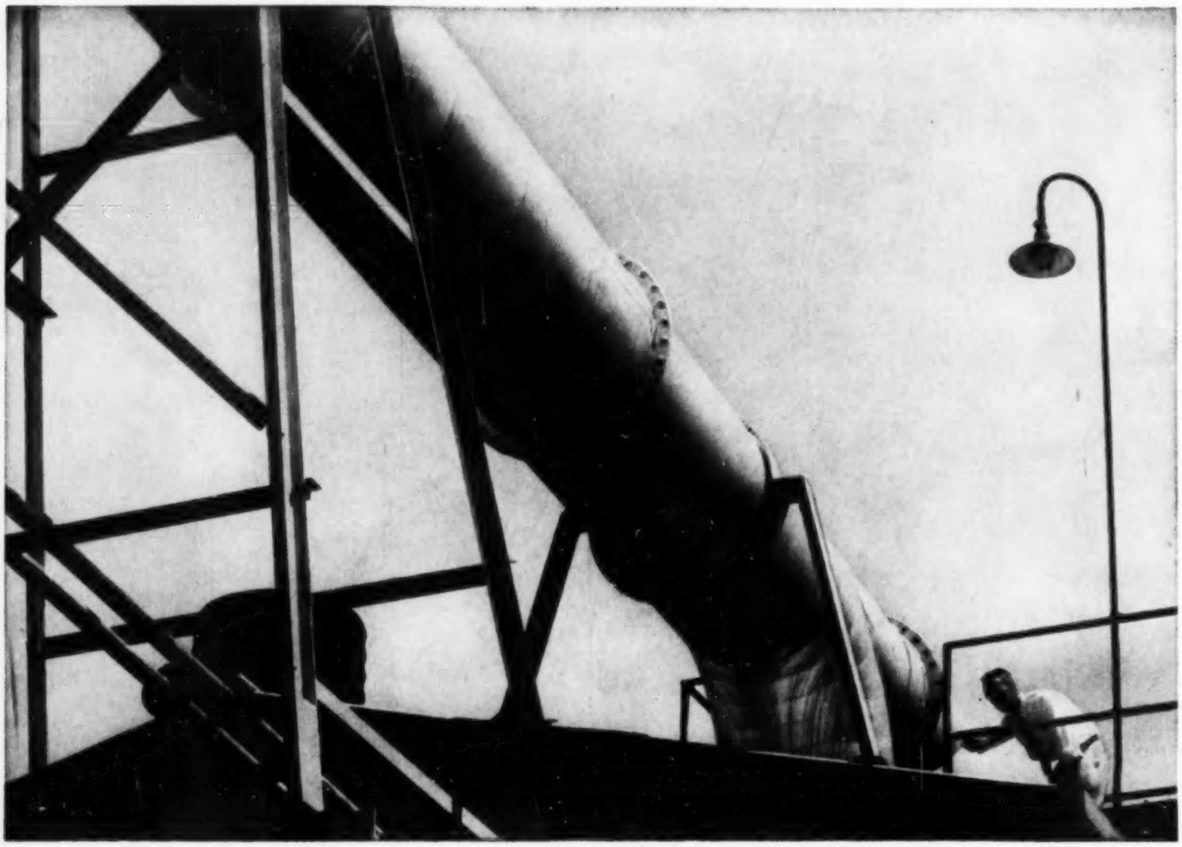

Chemical Engineering Progress

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LETTERS TO THE EDITOR

A Crushing Letter

The current chemical engineering literature should contain a discourse on the actual proof that Kick and Rittinger's laws are wrong. A recent attempt was made in "C.E.P." to do so in the article "Fundamental Aspects of Grinding," which appeared in the February issue.

This subject is sufficiently important, at least to the mining industries, to warrant a full-scale assault to prove the adequacy of the aforementioned theories. Discourses on crushing and grinding by mining men, i.e., the cold facts, not theory, would help.

For the further benefit of mining men, further research, both theoretically and experimentally, should be carried out on the problem of settling of particles in fluids. What with new theories being advanced constantly, the picture will become more confused unless a good research program is instigated. If a practical solution to this problem is made, it can be applied also to water purification and sewage disposal, two important phases of human existence. Remember, water purification processes will become more complicated when we consider radioactive particles, something we cannot disregard in these atomic-minded times.

2nd Lt. Nelson S. Gray
687th Engr. Water Supply co.
New York, N. Y.

A Member Speaks His Mind

Now for a gripe—let's dispense with articles on "How to Succeed," "What's the Matter with Us," "How Much Money Are We Making," and moralistic lectures. Too many comparisons only lead to dissatisfaction. Who are the great gods in our organization who are trying to create chemical engineers in their own images? Could we emphasize the man more and the cog less? How about an article on "Fit Your Job to you" instead of "Fit Yourself into the Job."

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At our Toronto meeting J. Watson Bain, professor emeritus of chemical engineering at the University of Toronto and the first professor of chemical engineering in Canada, was asked to greet the dinner guests. His remarks were so well received that Chemical Engineering Progress with Professor Bain's permission prints them here in Noted and Quoted as an example of delightful wit and a resumé of progress in the field of chemical engineering.

This is the season of spring house cleaning and the sound of the vacuum cleaner is heard in the land. He who supposes himself to be the head of the house arrives home from his office to find that the familiar aspect of the interior of his house has undergone a mysterious transformation and that his desk, his books, and other personal belongings are no longer ready for immediate use.

At such a season there are objects usually sitting upon an upper shelf which are taken down, carefully dusted and then replaced, sometimes with sentimental thought of days that are gone. Such an object am I. And after seven years on the upper shelf I have been taken down, carefully dusted, and will shortly ascend once more to the upper shelf.

From what I have heard and seen in the last two days, I trust that the house cleaning has been proceeding very thoroughly and I recognize that much new apparatus and many new methods are being used in the process. I have, as it were, been present at much of the building of the present structure of our profession and have sat in at many and sometimes acrimonious house cleanings. What I now see from my shelf rather appalls me, for I can't imagine how any one individual, however competent and industrious, can hope to master the great field of chemical engineering as it exists.

To you who bear the heat of the burden of the day, I can only offer my congratulations upon your energy and your initiative and hope that you may one and all find that your efforts have led you to happiness and prosperity.

I may now, perhaps, be permitted to ascend once more to the upper shelf.

J. Watson Bain

The Art of Writing

What are the requirements for a good scientific or technical book?

First of all, the writing must be ac-

(Continued on page 15)

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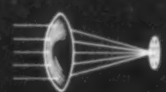

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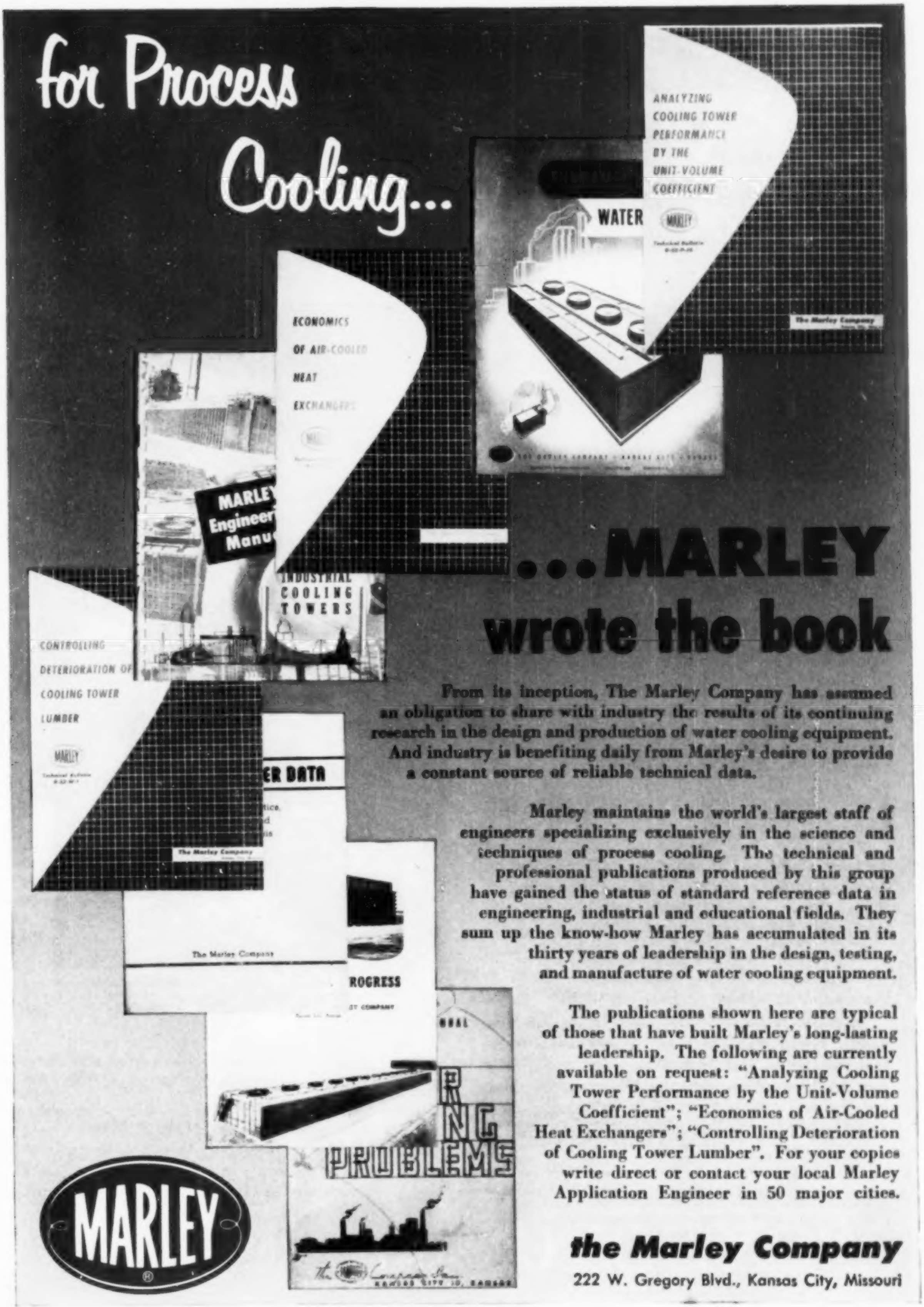
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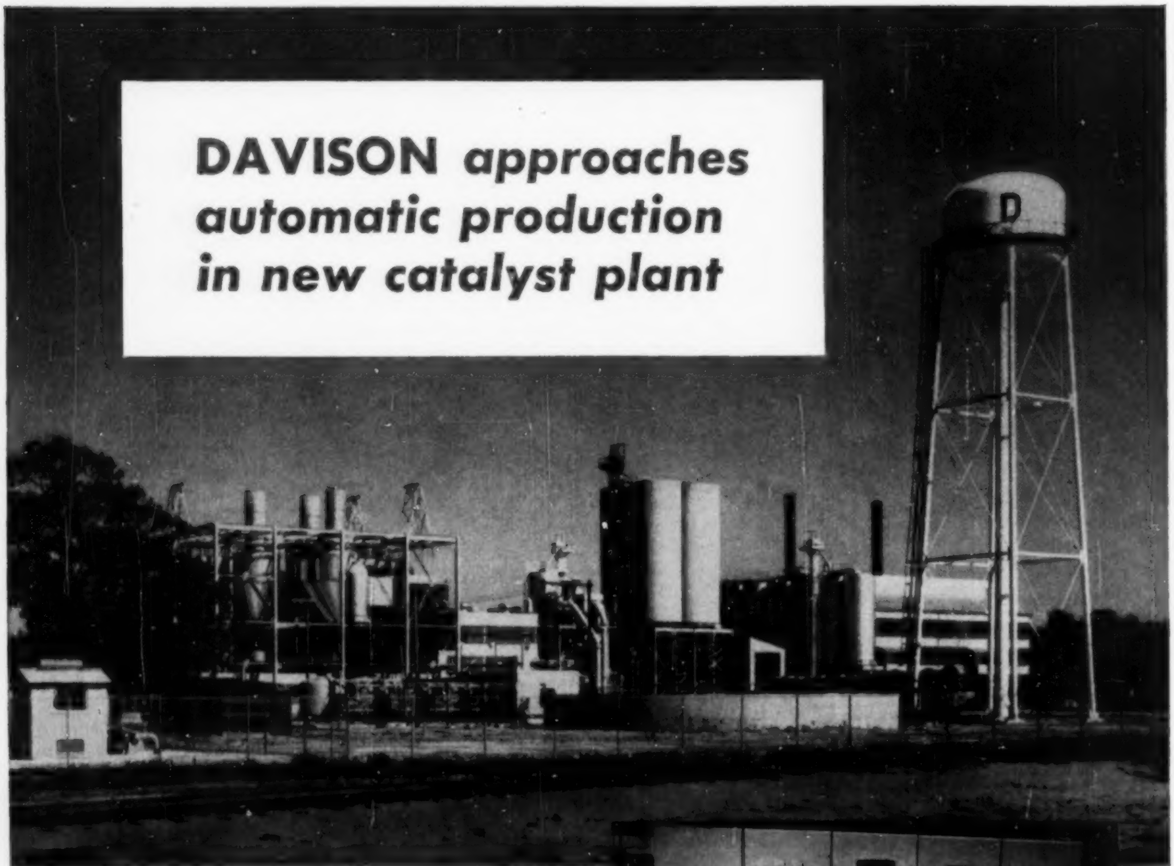

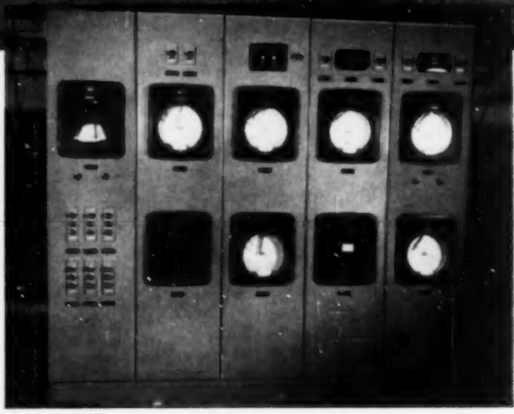

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(Continued from page 8)

Accurate. Scientific writing that is not accurate is nothing at all. It can become a kind of sloppy sentimentalism, sprinkled with a few scientific-looking words and phrases, that promises much but teaches little that is useful.

Secondly, the writing must be clear. This means that some technical words, new words, must be defined in terms of the reader's experience. Only terms that are really necessary should be used; but, even so, many cannot be avoided. A main purpose of scientific and technical writing is to explain new principles and new concepts. This means that new terms and phrases with specific meaning must be used. To avoid them, to write roundabout paragraphs each time they are involved, or to substitute older inaccurate terms, is to defeat the very purpose of the writing.

Charles E. Kellogg
The Wonderful World of Books

To Oversee

Is it not also true that those of us who have to do with the staffing of our industry are requiring engineering and scientific training for functions that, traditionally, have not been thought of as requiring such talent? Such areas include sales, market research, technical services, and many administrative posts. There are, of course, exceptions to this. But the idea is sound, and there is every indication that this trend will continue.

Thomas H. Chilton
Chairman, Engineering Manpower Commission

or Not to Oversee

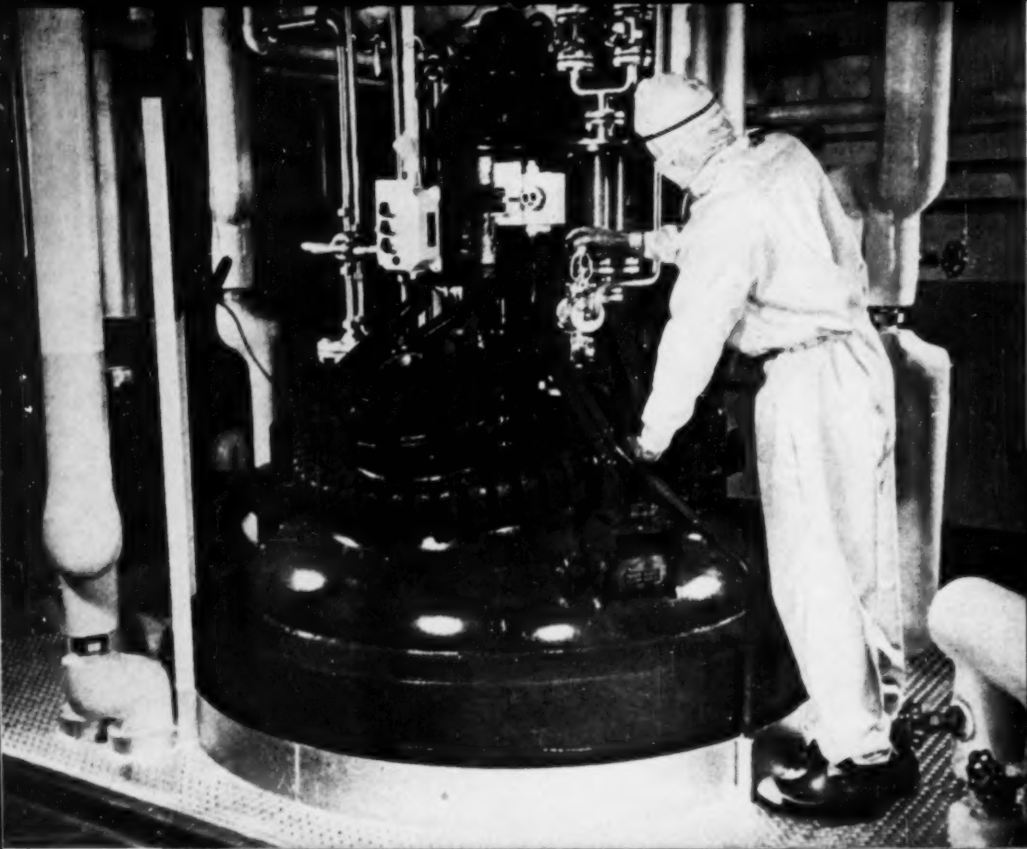
It is also a mistake to mix the administrative functions with the scientific functions of good research engineers. The top scientific men should be used for the jobs they are best qualified to hold—that is, the research jobs.

Leslie R. Groves
Vice-president, Remington Rand, Inc.

United We Fall

. . . Any collectivism, including our common concept of unionization, is incompatible with truly professional performance. Collective action, however highly conceived, will eventually result in a leveling process, and will inherently result in a strong influence toward mediocrity for the individual. At that point, the professional man loses some of this ingredient of individuality. The freedom that creates a vigorous professional attitude has begun to wither, and if the process continues indefinitely, it may die.

H. N. Muller, Jr.
Journal of Engineering Education



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Opinion and comment

The Write-in Analysis

Being an editor is a lonely business. It is not a matter of meeting too few people, it is a matter of not meeting often enough the true thoughts of people. No matter how many meetings an editor attends, how many letters he answers or receives, or telephone calls he answers in a day, the essential residual feeling about an editor's efforts is one of loneliness. Now perhaps we may be the only editor in the business who reacts this way. But each month after the 17,000 copies of "C.E.P." are in the mail we get a strong sense of expectancy. We wait for reactions—a lot of them. We wonder what 17,000 pairs of eyes see and what 17,000 minds think as they open and begin to read the current copy. Each month we bring out what, in our opinion, are the most important of all the facts and stimuli which pass under our hands and through our minds, and we wait for you, as a reader, to tell us what you thought and how you reacted.

Oh, we get letters, both the pleasant letters of compliment and the fretting letters of complaint, but not nearly so many as we expect. That feeling of waiting, that feeling of anticipation, that feeling of having sent out 17,000 little messengers, remains with us every month.

Of course, we don't believe that we are the only editor who has this difficulty in tapping the true feelings of readers. For proof of this one merely has to point to the numerous reader surveys as prima-facie evidence that the desire to know more is common among the publication fraternity. As a matter of fact there are firms specializing in such surveys, that for a price will interview a certain number of readers a month.

Chemical Engineering Progress also makes surveys of reader opinions. For several years we have been asking a number of members, via a mail questionnaire, for their opinion on what we do. It requires four pages of questions, and we keep close watch on the answers. Yet, opinion, like every other human response, can be measured and statistically forecast. After several years of questioning it is amazing how one can predict the pattern into which the answers will fall. And so, even questionnaires, after a while, leave the editor still probing the silence of the subscription lists, hoping always to find out what is liked and what is not liked. The slightest pencilled note on a returned questionnaire is deciphered and pondered over for here is a strong expression of opinion. Here is indication of a matter of such bothersome necessity that the customer writes a note. It doesn't matter whether the pencilled note is one of praise or complaint. It is interesting. Here, to the editorial hypodermic needle, is a reaction. Here, on the customer, is a wonderful red swelling, which indicates one thing—something we have done has pleased or displeased. And editors cluck, cluck over a reaction like busy doctors examining a rare itch.

Now all of the above is merely a prelude and an explanation of the editorial feelings about the comments made by A.I.Ch.E. members in the National Questionnaire. This month in our news pages we print the analysis of the written comments made by the members and interpreted by the National Survey Questionnaire Committee. Here were thousands of reactions—reactions on the grand scale.

Lloyd Smith and his committee deserve our applause for the effort and work which have gone into the questionnaires and the analysis of the results.

As we read over the manuscript, we were aware of the essential friendliness of those who commented, of a communicated desire only to help, and this was true also of the adverse remarks. Therefore, it moved us to write, in footnotes, our own reaction, explaining, only in cases where there was a misstatement of fact, what the real situation was.

All in all the reaction was one of elation in our destiny, a feeling of kinship with many, many friends, many, many chemical engineers, who were as much concerned about the Institute and the chemical engineering profession as we were. Here were the intimate thoughts of men for whom we had been writing for these past seven years. And whether the comments were favorable or unfavorable, the editor's reaction was one of thanks that so many cared so much about their professional organization as to write in what they believed was right or what they felt was wrong. The only possible result is a stronger and a better American Institute of Chemical Engineers, which is another way of saying a stronger and a better chemical engineering profession.

Perhaps, in the future, we, as editor, may have a returned feeling of separation, but allow us to assure everyone who took the trouble to write, that for a long, long time we will be well aware of the positive goals set and the many, many progressive things yet to be done. We thank you.

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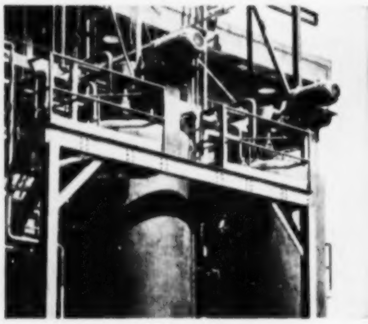

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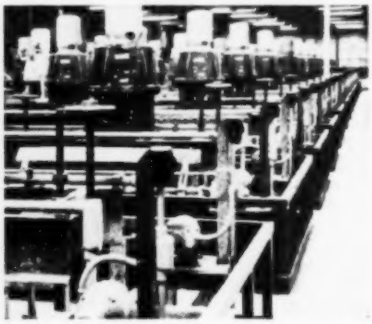

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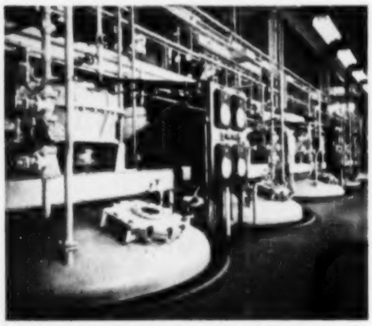
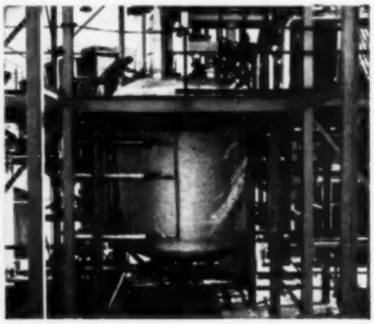


Turbo-Mixers used in antibiotics fermentation at Upjohn Company Plant.

Turbo aerators and floaters on phenolic treatment at GATC car washing plant.



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Design and Use of Ten-Kilocurie Source of Gamma Radiation

L. E. Brownell, W. W. Meinke, J. V. Nehemias, and E. W. Coleman

University of Michigan, Ann Arbor, Michigan

The operation of nuclear reactors such as those used in the production of plutonium, has produced large quantities of radioactive fission-product waste materials. These materials cannot be used in the atomic-bomb program nor can they be disposed of, as is customary with ordinary industrial waste, that is, they cannot be discharged into streams or rivers, dumped on the ground, or released into the air by burning because of the hazard of contaminating air and water supplies and food materials with radioactive poisons.

As a result, the Atomic Energy Commission has been storing large quantities of these fission products in underground tanks designed to retain this material for many years. The problem of disposing of these fission products will become more important as the reactor program increases. If the fission products could be put to use in industry, what is at present an expensive waste material might be turned into an asset with the saving of taxpayer dollars.

Since the Stanford Research Institute report (*11*) was isued, considerable interest has developed in the possible industrial uses of waste fission products. The Atomic Energy Commission has contracted with various universities to investigate some of these uses. In June, 1951, Michigan and later other universities (*1*) received kilocurie cobalt-60 sources from the Brookhaven National Laboratory of the type described by Manowitz (*9*). The Michigan kilocurie source (see Fig. 1) was installed in the Fission Products Laboratory of Engineering Research Institute, University of Michigan, and a variety of experiments has been conducted and reported to the Commission (*2-5*). Additional experiments have been supported by the Michigan Memorial Phoenix Project.†

The 1000-curie source has proved to be a useful laboratory tool in the experiments which have been conducted during the past eighteen months. During this period, this source of radiation has been in use seven days a week, 24 hours a day, with few exceptions. The research has been limited by the availability of radiation time. Only a small percentage of radiation from the 1000-kilocurie source of cobalt-60 can be absorbed by the specimen placed in the radiation chamber. The small internal diameter of about 1½ in. has greatly limited the size of the sample which might be irradiated and has made it difficult or impossible to conduct many experiments. Therefore, a decision was made to secure another gamma-ray source of greater flexibility.

First, it was decided that the design should be modified so that a greater percentage of the radiation would be usable. A modification in which samples could be placed around the exterior of the cylinder as well as within the cylinder was a step in this direction. The internal diameter of the source was increased so that larger samples could be irradiated within the cylinder or on the outside of the cylinder. Chemical reactors for gases reacted under pressure will be used in some experiments. Equipment for this service is much easier to fabricate and control, and less expensive if some flexibility in size is permitted.

In the experiments with irradiated food, it is desirable to place commercial-size cans in the irradiation chamber. It was found that preservation of food by irradiation involves many problems other than sterilization as experienced in the canning industry and also that irradiated food must be protected from oxidation, dehydration, etc. as in the canning operation. Prior to use of the

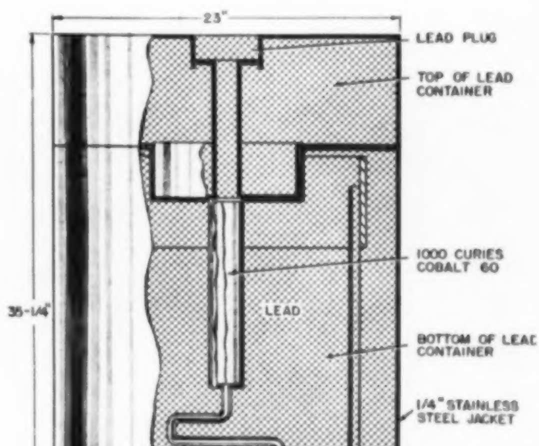


Fig. 1. Sectional view of the container for the Michigan one-kilocurie source.

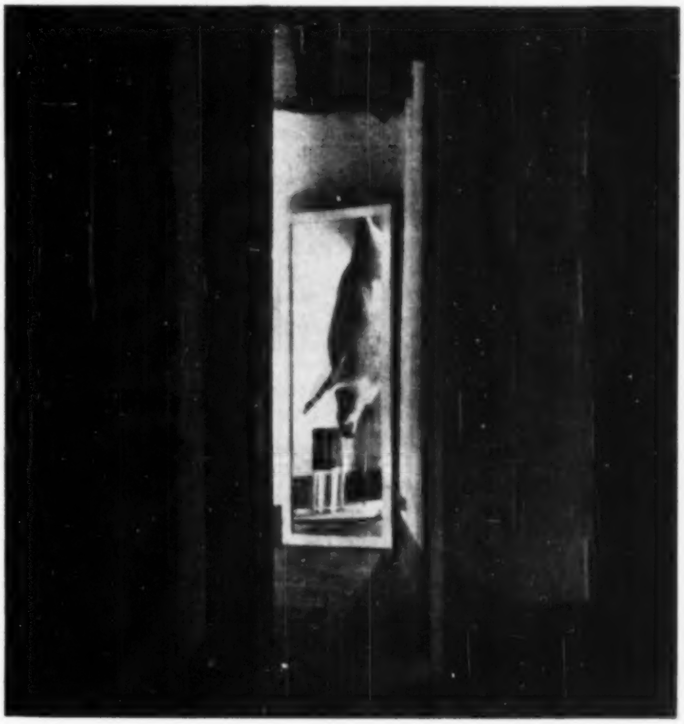
† This project is a memorial to the Michigan dead of World War II.

Figure B shows Brownell inside the cave with his hands on a No. 10 can of food to be irradiated. The cans are set on small turntables shown at the bottom and are rotated to produce more uniform irradiation. Meinke is checking the radiation field. The source is in the down position (not shown). However, in the raised position it is within the wire cage (lower right). ▼

▲ Figure A shows the entrance to the radiation cave with the authors of the accompanying article, all of whom are associated with the Fission Products Laboratory, Engineering Research Institute, University of Michigan. L. E. Brownell, associate professor of chemical engineering and director of the laboratory, is at the far left holding two No. 10 cans of food to be taken into the radiation cave for irradiation. W. W. Meinke is standing next to him with a portable survey meter, which is always taken into the cave as a routine procedure to check the radiation field and thereby assure that a source is in the down position. He is assistant professor of chemistry and research adviser. In the center (seated) is research assistant Eugene Coleman, who is entering in the logbook the time of lowering the source. At the far right is J. V. Nehemias, research associate and health physicist, who has just lowered the source by means of the winch shown at the right.

◄ Figure C illustrates Brownell and Meinke at a work bench in the laboratory outside the cave. Brownell is holding an aluminum rack similar to that used to hold the 100 cobalt rods. Meinke, right, is holding in his hand a cobalt rod which was not made radioactive. In the background are some samples of irradiated food.

Last March readers of *Life* were treated to a color photograph showing six samples of food, three in advanced stages of disintegration, the other three still succulent and appetizing. This was "everyman's" resumé of the work of Lloyd E. Brownell and associates at the University of Michigan on the use of radioactive cobalt for the preservation of food. The rest of the pictorial study on Brownell showed a mouse being fed irradiated milk to prove that food treated with radiation is harmless, as well as the two illustrations reproduced in this article. The first one, on this page, is a mirror view of a half hog being irradiated; the rod near the pig's nose is the radioactive cobalt. The other, the diagram on page 572, shows the radiation cave and labyrinth extremes.



Chemical Engineering Progress now presents here the technical report of Brownell's research, work which has been going on at the Fission Products Laboratory of the University of Michigan, for about two years. In January of this year, the laboratory received a 10-kilocurie source of cobalt 60 from Chalk River, Canada. This source, the largest experimental gamma source yet produced, according to Brownell, consists of one hundred cobalt rods 1/4 in. in diameter and 10 in. in length, encased in 3/8-in. aluminum pipe. The cobalt rods are assembled in a double circle 7 3/18 in. I.D., and the radiation field both inside and outside the circle is made available for experiments as illustrated on page 572. To turn off the radioactivity it is, so to speak, lowered into a pit of water 16 ft. deep.

To destroy the more resistant microorganism in food, about 3,000,000 rep. (roentgen equivalent physical) is needed. As for irradiating a hog—only a small dose will break completely the cycle of trichinosis in contaminated pork.

Little is known of what the future holds for food processors in the use of gamma radiation sources, but it is from research such as this that large industries spring. Nor are the chemical processors out in the cold in this modern field. In the discussion Brownell reports on the chlorination of liquid benzene, which proceeds with extra rapidity under gamma radiation to form benzene hexachloride. Pharmaceuticals themselves have been irradiated by this source and were successfully sterilized; only one showed a loss of potency.

These and other uses are being investigated by the chemical engineers from the Laboratory, and Brownell points out for the process industries, one obvious advantage of gamma rays as a chemical reactor; they will pass through the walls of pressure vessels and do not confine themselves to surface reactions, since they penetrate all parts of the mixture.

10,000-curie source, it was necessary to limit all food tests to food packaged in glass test tubes or plastic containers because the 1000-curie source will not accommodate the smallest size of tin can. In the experiments on food sterilization the gamma flux must have sufficient strength so that the irradiation time will be short enough to assure nonspoilage of the irradiated sample before sterilization can be accomplished. With these considerations it was decided that a cylindrical radiation source of at least 10 kilocuries would be required and that this source should be designed to irradiate samples both outside and inside the cylinder. For added versatility it was decided that this source should be in the form of a number of rods which could be set into a cylindrical pattern or into a layer pattern, depending on what was desired.

A few comments regarding the efficiency of using gamma radiation sources might be mentioned. As the intensity of the gamma-ray source is increased, it can be used more efficiently, since a greater percentage of the radiation field can be used. For example, a 1-curie source is practically useless in promoting chemical reactions or sterilizing biological materials because the field is of such low intensity; whereas a 1-kilocurie source can be used for these purposes, as has been demonstrated in this laboratory and others. The new 10-kilocurie source, however, is estimated to be about thirty times as useful as the present 1-kilocurie source because, in addition to having ten times the radiation intensity, it is estimated that about three times as much of the total radiation emitted can be absorbed by experimental samples.

Upon inquiry, it was found that during the latter part of 1952 all reactors in the United States having a neutron flux sufficiently high to provide 10 kilocuries of cobalt activity in a reasonable period of time had scheduled radiation services for several months in advance. Rather than postpone the procurement of a larger source, the possibility of obtaining the irradiation in the Chalk River NRX reactor was explored and the arrangements were made for the irradiation.

DESIGN OF COBALT RODS FOR 10,000-CURIE SOURCE

The source consists of 100 cobalt rods, ¼ in. in diam. and 10 in. long. These high-purity cobalt rods, fabricated and machined to close tolerances by the Kulite Tungsten Co., were encapsulated in ⅛ in. nominal size 3S-H18 aluminum pipe, 0.269-in. I.D., with a wall thickness of 0.068 in. and an O.D. of 0.405 in. The ends of the rods were welded with Alcan 2S welding rod, machined clean, and tested for leaks by dropping the complete rod into hot water.

The rods were inserted into the Chalk River reactor during July, 1952. Initial specifications called for the 10-kilocurie source to be produced in an irradiation period of 4½ months using the 100 rods. The curie was defined as the activity obtained from calculations based on a total amount of "nvt" exposure, with consideration given to irradiation efficiency. The further restriction was made that no one rod of the 100 irradiated was to be more than twice as active as any other rod—thus insuring a fairly even radiation field in the assembled source.

DESIGN OF CAVE FOR 10,000 CURIES

Although it was relatively simple to determine the shape and size of the cobalt rods for the 10,000-curie source, it was more difficult to decide how this source should be contained and shielded, and how experimental samples were to be brought into the radiation field with the minimum of danger to operating personnel and the maximum of flexibility regarding experimental procedures. Several designs, including such ideas as lowering experimental samples down through charging tubes into the radiation field, use of shielded ports, etc., were investigated and discarded. The final decision was that the most flexible method was to have the source in a radiation room or chamber.

With such an installation, it was necessary to provide some means of "shutting off" the radiation from the source so that laboratory personnel could set up experimental equipment. It was decided that the most convenient method of shutting off the radiation from the area would be to submerge the source in a "well" of water. This permits the setting-up of experimental equipment in a room free from radiation. After laboratory personnel leave the room, the source is raised and the experimental irradiation performed. Figure 2 shows a cutaway or phantom view of the radiation "cave" for 10,000 curies of cobalt-60.

DETAILS OF CAVE DESIGN

Figure 3 shows a plan of the radiation cave. Essential features are the 4-ft. thick concrete walls necessary to shield both laboratory personnel and the surrounding area from gamma radiation and the 16-ft. well used for shutting off the source. The 4-ft. barrier wall provides a simple labyrinthine entrance and prevents the source from "seeing" the door. The barrier wall serves to diminish the radiation flux in the labyrinthine entrance so that a heavily shielded door is not required. The door is provided with a mechanical safety interlock, making entrance to the radiation cave when the source is in the raised position, impossible. In addition to the safety provided by this interlock, a safety light immediately above the locking bar handle serves to indicate the position of the 10,000-curie source. This device is activated mechanically by the rods of the source itself. As the source is raised to its uppermost position, it contacts a vertical rod which is raised by the final travel of the source and which through a cable indicates the position of the source. Therefore, these two different mechanisms operate independently. These safety measures are supplemented by rigorous monitoring with instruments upon entry into the cave.

DETAILS OF LIFT AND HOLDER FOR COBALT RODS

Two ½-in. diam. 18-8 stainless steel rods serve to raise and lower the cobalt source. A small pedestal is welded to the lift platform so that the bottom of the cobalt rods will be about 12 in. above the floor of the radiation cave when the source is in the raised position.

The holder for the rods is shown in Figure 4. The holder is constructed of fabric-reinforced phenolic plastic which serves to insulate the rods from contact with the elevator and from each other. The hundred rods are placed in two concentric circles spaced as close together as possible.

PHOTOGRAPHS OF THE CAVE AND ACCESSORIES OF COBALT-60 SOURCE

A series of photographs was taken to aid in describing the construction and operation of the cave and the accessory equipment. For ease in assembling and to minimize the difficulty of future disassembling, the 4-ft. concrete walls were constructed in the main part of solid 8 x 8 x 16 concrete blocks with mortar joints. Alternate rows were filled with poured concrete; however, the outside rows were all of block construction. The blocks were staggered vertically to minimize radiation through the mortar joints. Also in each successive course the rows containing poured concrete were alternated.

Figure 5 is a photograph taken looking down into the well before it was filled with water. The elevator is shown in the partly raised position with the holder for the rods in place. The plastic (Lucite) cap is shown in Figure 6. This serves to prevent any potentially contaminated water from dripping off the rods and the rod holder (shown inside the Lucite cap) and splattering on the experimental samples as the source is raised. The Lucite insert in the center of the Lucite cap holds samples in the center position of maximum flux.

SHIELDING CONSIDERATIONS

After consideration of the various experiments which were anticipated, it was decided that the radiation cave would be 8 ft. square; which places the inner surface of the shield wall 4 ft. from the center of the source. With the shield so situated, it was necessary to determine the thickness of concrete required to reduce the radiation levels at the outside surface to values safely below tolerance.

Figure 7 shows the effects of various thicknesses of concrete at various positions based on predicted dosage rates and computations (*5, 10*). The dotted line indicates the dosage rate outside a concrete shield as a function of shield thickness for a design in which the inner face of the shield is 4 ft. from the source.

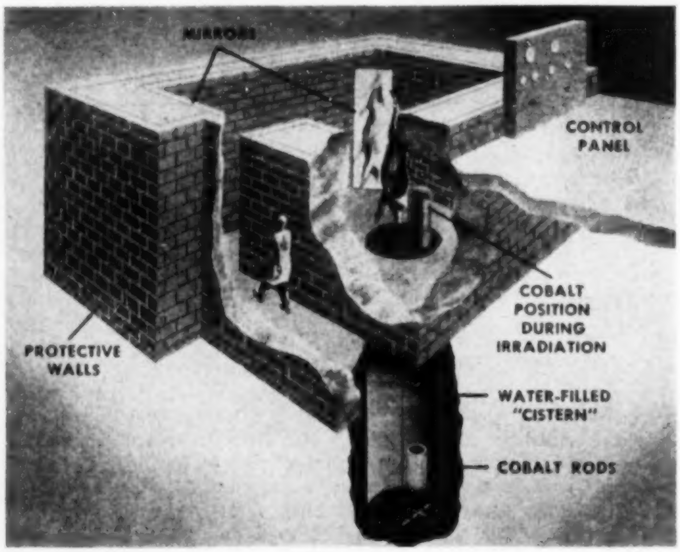


Fig. 2. Phantom view of radiation cave for 10,000 curies of cobalt-60.

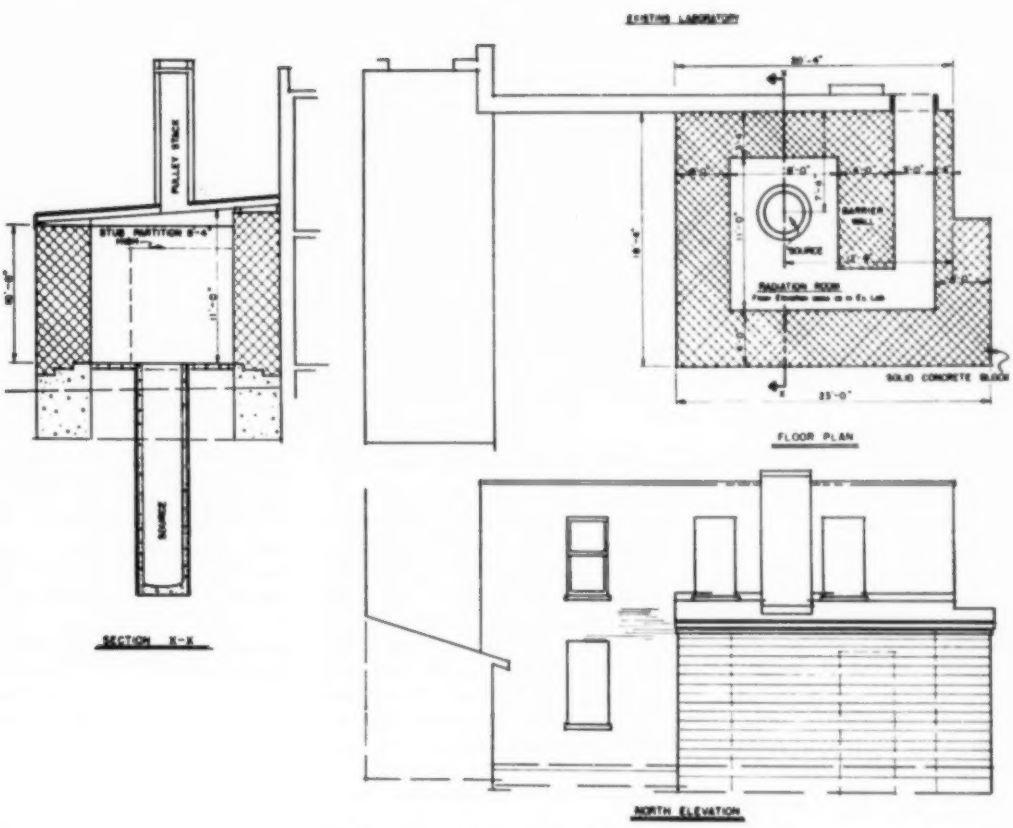


Fig. 3. Plan and elevation of radiation cave.

As the outer surface is accessible to the general public, a maximum dosage rate of 1.0 mr./hr. was considered permissible. However, there was also the consideration that it is convenient to lay concrete walls in units of 8 in. thickness, therefore a thickness of 48 in. (4 ft.) of concrete was selected for the shielding walls. The estimated dosage rate at the outer surface of such a shield wall would be less than 0.3 mr./hr.

The source is lowered into a well of water 3 ft. in diam. and of sufficient depth to make it possible for workers to enter the cave without hazard. To determine the required depth of the well a set of calculations similar to those applied to the concrete shielding resulted in the predicted dosage rates shown in Figure 8. On the basis of these calculations a shielding thickness of 11 ft. was considered sufficient. However, besides shielding thickness an additional 5 ft. of depth are required partly for manipulation space at the top and bottom of the well and partly to provide space for the lift mechanism. Therefore, a 16-ft. well was prepared.

USES OF RADIATION

The future availability of large amounts of radioactive wastes makes it possible to consider irradiation as a new process. The question with which we are presently concerned is that of how this new irradiation process may be used to advantage. Preliminary studies at Michigan have indicated that radiation can be used to advantage to sterilize food and pharmaceuticals and to promote chemical reactions.

a. Destruction of Microorganisms

Tests were conducted at Michigan with a variety of microorganisms such as yeast, molds, spore-forming and non-spore-forming bacteria, with virus and with higher forms of organisms such as the larvae of *Trichinella spiralis* and these have indicated that gamma radiation is lethal to all these organisms. Figure 9 shows some typical observations with molds made by C. A. Lawrence, assistant professor of bacteriology and co-workers (*8*). At the left of Figure 9 two petri dishes are shown with normal growths of two common molds, *Aspergillus niger* and *Penicil-*

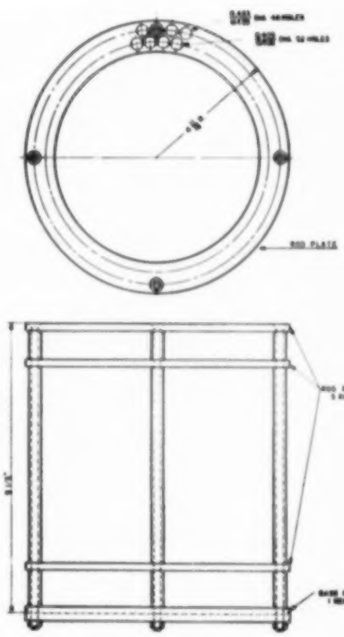


Fig. 4. Rod holder assembly.

lum notatum. The two petri dishes at the right are free of any mold growth as a result of irradiation of the culture.

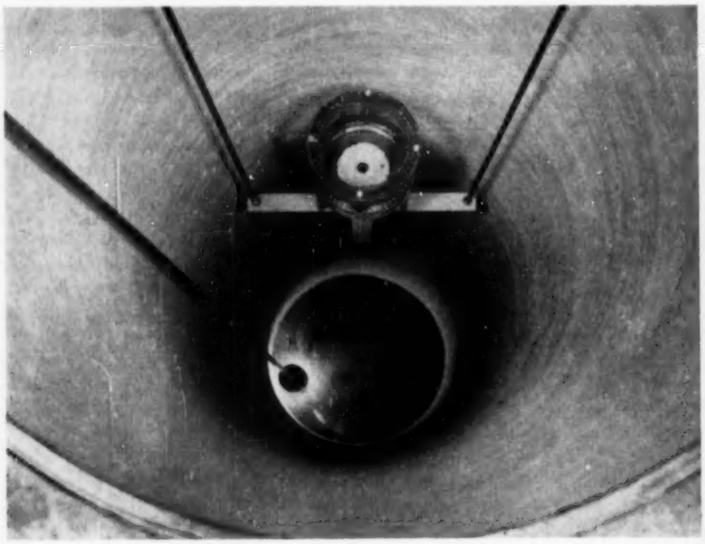
b. Sterilization of Foods

The sterilization of food probably is the greatest single potential use of radiation. However, this use probably has a greater number of problems to be solved than the sterilization of pharmaceuticals and other biological products. In the Fission Products Laboratory food has been packaged in plastic containers and in glass tubes and preserved from spoilage by microorganisms for many months (*6*). Vegetables such as peas, spinach, asparagus, broccoli, carrots, etc., seem to be the most satisfactory foods for preservation by irradiation. In the studies made in the Fission Products Laboratory it was found that these foods undergo little flavor change; in fact the peas and carrots seem to be slightly sweeter and are definitely more tender as a result of irradiation. There is a tendency to bleach, which is a disadvantage in the case of green peas, but may not be a disadvantage in the case of asparagus and carrots. There also seems to be a softening of the foods with a certain amount of cell destruction, as evidenced by an increase in tenderness, a decrease in crispness, and the loss of some fluid from the cell. For example, irradiated peas cooked for three minutes have the same tenderness as the control cooked for six minutes.

Flavor tests made in the Fission Products Laboratory indicated that protein foods of animal origin are not so satisfactory as fresh vegetables when treated by irradiation. In general, protein foods of animal origin undergo two types of flavor change; the proteins develop a strong animal-like odor and taste, and the fats develop a tallowy or rancid odor and taste. These off-odors and off-flavors are quite volatile and in many instances disappear upon cooking. However, there seems to be little promise at present of irradiating foods such as milk, cottage cheese, and eggs without developing off-flavors that would be objectionable to a large percentage of the public, although some individuals are unable to detect these off-flavors except when great dosages of radiation have been used. Rats fed irradiated milk accepted it as readily as the control.

It was discovered that irradiated bacon, ham, and corned beef were relatively free of any off-flavors after these products were irradiated and then cooked. Representatives of a major packing company tested samples of irradiated bacon, corned beef, and ham and stated that the bacon had flavor which would be quite acceptable and that the corned beef was good. The ham which was tested seemed to have a slight off-flavor of irradiation. However, other hams have been tested, which were found to have no off-flavors after irradiation and cooking. It was believed that sodium nitrite and nitrate used in processing these meats protected the flavor molecules during irradiation. Other tests have been made using sodium nitrate with raw ground beef, and a noticeable improvement in flavor was observed. Concentrations of sodium nitrite as low as 100 p.p.m. appear to be effective in preventing flavor change. The Food and Drug Administration permits up to 200 p.p.m. of sodium nitrite in meats cured using sodium and/or sodium nitrate. One hundred parts per million of sodium nitrite does not affect the flavor of raw meat when cooked but does have a tendency to give the cooked meat a reddish rather than a greyish color.

The gradual trend in the food industry is toward the processing of more and more food to cut the losses of handling perishable foods. Radiation sterilization is a possible new method of processing foods, which might assist this trend as a supplement to existing processes. Canned food of better quality may be possible if radiation sterilization rather than thermal sterilization is used. Radiation pasteurization of some perishable foods may make it possible to keep refrigerated foods for longer periods of time. It would seem that the successful development of a process of radiation sterilization would be beneficial to the country as a whole. However, three important steps must be taken before food can be preserved by gamma radiation on a commercial basis: (1) food sterilized by gamma radiation



▲ Fig. 5. Photograph of well.

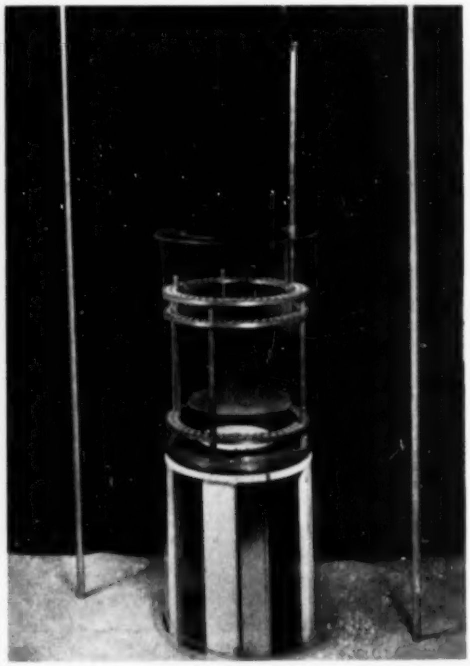


Fig. 6. Photograph of Lucite cap. ▶

must be proved acceptable to the Food and Drug Administration's requirements and to consumers' tastes; (2) industry must show an interest by supporting research work to develop the process in terms of commercial feasibility; and, (3) the Atomic Energy Commission must make suitable fission-product gamma-ray sources available in sufficient quantities and at reasonable costs.

c. Sterilization of Pharmaceuticals

In studies in which pharmaceuticals were irradiated, it was found that various vitamins, toxins and antitoxins, hormones, and antibiotics can be sterilized. Only one pharmaceutical, one of the pituitary hormones, showed any appreciable loss in potency as a result of the irradiation. It was observed, however, that the glass ampoules discolored to such an extent that the representatives of the pharmaceutical industry considered the discolored ampoules unsatisfactory for commercial use. Some special glasses were tested and it was found that an experimental glass produced by the Corning Glass Works would be satisfactory. This glass can be worked into ampoules as readily as the glass presently used, was found to meet U. S. P. requirements, and is free of color change after an irradiation dose of more than four million rep. (roentgen equivalent physical).

Another study in progress is the sterilization of blood products by gamma radiation. Some pooled blood and blood products have been found to contain harmful viruses which cannot be removed by conventional sterilization methods without destruction of the blood products. Gamma radiation has been found to be lethal to other viruses, and it is believed possible to destroy this particular virus in the blood products in a like manner.

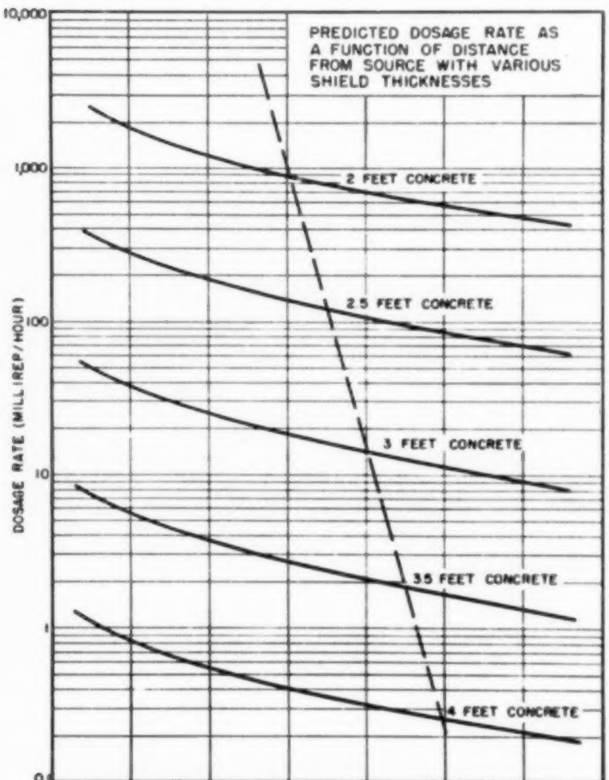
d. Effect of Radiation on Trichina Larvae

In studies at the University of Michigan, conducted by H. J. Gomberg and S. E. Gould, it has been found that ionizing radiation is effective in preventing the normal development of the causative agent of trichinosis (*Trichinella spiralis*) (*7*).

Irradiation of trichina larvae in infected meat with either 200 kv. X-rays or cobalt-60 gamma rays (1.17 and 1.31 Mev) is effective in producing the following results, depending on the dose employed:

1. The larvae can be killed by a radiation dose of one million roentgens.
2. Maturation of the larvae to adult forms is inhibited by cobalt-60 gamma rays in a dose of 18,000 roentgens and by a 200 kv. X-ray dose of 14,000 roentgens.
3. Female adult forms which develop from the irradiated larvae are sexually sterile if the dose of gamma rays is 12,000 roentgens or the dose of X-rays is 7,000 roentgens.

These results indicate a new approach to the problem of prevention of trichinous infection in man. To contract trichinosis, a person must ingest meat (principally pork), containing live trichina larvae. The larvae develop into sexually mature adult forms in the small intestine where they reproduce, the new generation of larvae entering the tissues of the host, ultimately encysting in his voluntary muscles. For each ingested larva which develops into an adult form in the intestine of the host, approximately one thousand larvae of the second generation are produced. This critical phase of the development of the parasite in the intestine of the host can be inhibited and the infection prevented



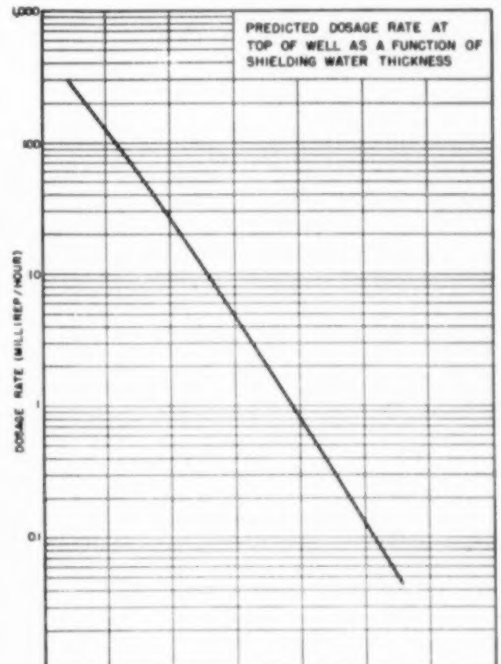


Fig. 7. (Left) Predicted dosage rate as a function of distance from source with various shield thicknesses (for concrete).

Fig. 8. (Above) Predicted dosage rate as a function of distance from source with various shield thicknesses (for water).

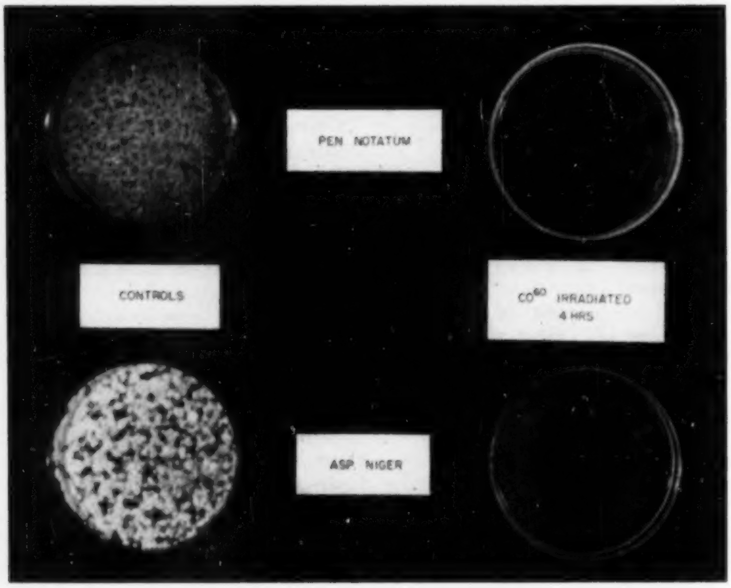


Fig. 9. Effect of gamma radiation on common molds.

by irradiation of the meat, before ingestion, at the relatively low-dose levels previously mentioned (up to 20,000 R).

The penetrating power of gamma radiation makes it possible to irradiate large sections of meat such as hog carcasses, thus providing a direct method of breaking the trichina cycle.

e. Promotion of Chemical Reactions

To the chemical engineer the most interesting potential industrial use of radiation is the promotion of certain chemical reactions. To this extent radiation should be considered a sort of catalyst rather than a source of energy. A radiation dose of one megarep will be delivered in about three hours in the region of greatest flux (the center) from the 10-kilocurie source. This is an appreciable radiation dose; however it represents only about 3.6 B. t. u./lb., assuming complete conversion to heat. Therefore, radiation is not a satisfactory substitute for heat or other forms of energy used to promote certain reactions. Ionizing radiation has the ability to remove electrons from the outer electron ring and thereby ionize and activate atoms, molecules and radicals which may then react with sufficient vigor to start a chain of reactions.

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Discussion

A. J. Arker (General Electric Co., Knolls Atomic Power Lab., Schenectady, N. Y.): Have your studies, or at least the theoretical aspects of them gone to the point of considering the problems of disposal of the fission products after they have decayed sufficiently so that they are no longer useful for the specific purpose for which an industry might purchase them?

L. E. Brownell: That question has caused some concern. Actually, to the best of my knowledge, no policy has been established on how the fission products will be handled. Presumably, they might be concentrated, packaged in containers of suitable size, perhaps 10,000 or 100,000 curies per container and sold to industry, or, the suggestion has been made to the Commission, that they might be rented. The fission products will have to be kept for a long period of time. After they are used for a given purpose, they will still be radioactive. If the fission products are sold there is no doubt that the Commission will require a good accounting of all radioactive material.

Jack Elliott (Dow Chemical Co., Freeport, Tex.): You mentioned in one of your earlier slides that the irradiation of meat had affected the flavor. Was it to the extent of making it inedible?

L. E. Brownell: The flavor is an "off" one. It is hard to describe because it is different from anything else ever tasted—somewhat burned, perhaps, and an animal-like or goaty taste which does not improve the flavor of the meat. However, some irradiated hamburgers had only a slight off-flavor. The extent of the flavor change can be minimized by treating the meat with ascorbic acid, or by treating it with a small amount of sodium nitrite. A variety of free radical acceptors might be used to minimize flavor change. The formation of hydrogen and hydroxyl free-radicals in the meat as the result of radiation, is believed to cause some of these flavor changes, and if one can add free radical acceptors to items like chopped meat, it is possible to minimize this undesirable flavor change. Although the irradiation of meat has more problems than irradiation of vegetables, because of flavor change, it is believed possible to prevent these flavor changes.

C. G. Ruderhausen (Du Pont Explosives Department, Gibbstown, N. J.): To what degree was the chlorination of benzene affected by radiation? Was the yield enhanced, and was the rate of reaction appreciably increased?

L. E. Brownell: The reaction proceeds rapidly. The experiments were started with liquid benzene, and, in the first experiment the product went completely solid after a few minutes of chlorination in the presence of gamma radiation. The rate of reaction has not been established and is the subject of current investigation. The chlorination of benzene in the presence of gamma radiation proceeds uniformly. It is not a surface reaction because the gamma radiation penetrates to all parts and wherever the benzene and chlorine are in contact, reaction occurs. This uniformity of reaction may be one of the advanatges of gamma radiation over ultraviolet radiation. Another advantage of gamma radiation is that it will pass through the walls of pressure vessels, which may make it possible to use gamma radiation to promote reactions under pressure.

Presented at A.I.Ch.E. Biloxi meeting.

Filtration Resistance of Compressible Materials

W. L. Ingmanson, the author of the accompanying paper, is a research assistant at the Institute of Paper Chemistry, Appleton, Wisconsin, where he is associated with the chemical engineering group working in research projects in the filtration field. Active in the academic program there, he teaches fluid mechanics.

An equation relating filtration resistance with important physical properties of compressible materials has been developed. The basic assumption in the derivation was that the classical Kozeny-Carman equation, designed for use in porous-bed permeability studies, would apply to the dynamic case of a constant-pressure filtration, provided that it was written in the differential form and properly integrated. The equation was corroborated by experimental data obtained in static (preformed bed) and dynamic (filtration) studies with nonflocculated beds of wood pulp fibers. It was concluded that the average specific filtration resistance in the ranges of applicability of the Kozeny-Carman equation is directly proportional to the square of the specific surface of the bed particles, and is related to the frictional pressure drop across the bed by a complex porosity function, which is dependent upon the effective specific volume and the compressibility of the material in question.

The correlation of filtration resistance with certain physical properties of particles as expressed by permeability equations, such as the familiar Kozeny-Carman equation, has led to an increased understanding of the nature of filtration resistance and of the mechanism of filtration. The relationships for noncompressible materials have been substantially validated. However, compressible particles or beds present a unique problem in attempts to apply permeability observations from a preformed or static bed to filtration conditions with a continually changing or dynamic bed, mainly because of a variation in porosity throughout the bed under any dynamic conditions.

Ruth (*17, 18*) and Carman (*5*) have presented equations which relate specific filtration resistance and specific permeation resistance. Carman (*5*) pointed out that it is not known if the point porosity function, as expressed by the Kozeny-Carman equation, holds for the dynamic case of filtration.

It was the aim of this study to obtain direct experimental data to substantiate Carman's original viewpoint, namely, that dynamic filtration principles may be related, through the use of the Kozeny-Carman equation, to the important particle properties of specific surface, effective specific volume, and compressibility.

Previous Work

Carman (*5*), Heertjes (*10*), and Miller (*15*) have presented reviews of the fundamental principles of filtration, methods of correlating and analyzing filtration data, and the nature of specific filtration resistance. Hoffing and Lockhart (*11*) recently presented experimental data which confirm Carman's original hypothesis of the equivalence of specific filtration resistance and specific permeation resistance for noncompressible materials.

Both Ruth (*17*) and Carman (*5*) have shown that, although the point specific filtration resistance of *compressible* particles varies throughout the bed, it may be assigned an average value for the whole bed. This mean specific resistance is the filtration resistance defined by conventional filtration rate equations, and is a function of the frictional pressure drop across the bed.

Ruth (*18*) found that the average specific resistance of the slightly compressible calcium carbonate, calculated from permeability data, differed by 10 to 15% from that derived from constant-pressure filtration data. Ruth felt that this discrepancy was attributable to an aging effect on the compressibility of the calcium carbonate. Ruth's calculation of filtration resistance from permeability data did not depend upon evaluating the permeation resistance in terms of porosity and specific surface. Therefore, no conclusions may be drawn from Ruth's data concerning the role of these variables in determining filtration resistance.

Walas (*23*) developed an empirical equation, giving the average specific resistance of nine compressible materials as a function of the effective particle diameter. His equation is not in agreement with the well-established Kozeny equation. Because Walas assumed that a mean porosity can be calculated from over-all cake dimensions, the significance of his equation is doubtful.

Kozeny-Carman Relationship

The most successful relationship expressing the permeability of porous beds as a function of certain physical properties of the material composing the bed was proposed originally by Kozeny (*12*), later developed by Fair and Hatch (*8*) and subsequently modified by Carman (*4*). One form of the Kozeny-Carman equation is

$$\frac{dV}{d\theta} = \frac{A \Delta P_f \epsilon^3}{\mu L k S_o^2 (1-\epsilon)^2} \tag{1}$$

where

V is the volume of an indifferent noncompressible fluid flowing in time θ past a cross-sectional area A

ΔP_f is the frictional pressure drop across the bed

μ is the fluid viscosity

L is the thickness of the bed

The factor k is called the Kozeny constant and is dependent only upon the shape of the pores and the ratio of the tortuous length the fluid traverses in passing through the bed to the actual length of the bed. The specific surface, defined as external area per unit volume of particles is S_o, and ϵ is the porosity, defined as the volume of the voids per unit volume of bed.

A more convenient form of the Kozeny-Carman equation, for the purposes of this study, is obtained by noting that the porosity, ϵ, can be expressed in terms of the concentration of solids in the bed, C, and the effective specific volume, v. Thus, $\epsilon = 1 - vC$. If the specific surface is defined as area per unit mass of particles, S_w, then $S_o = S_w/v$. Also, the length of the bed, L, can be written as $L = W/CA$ where W is the mass of fibers in the bed at time θ. Substituting for ϵ, S_o, and L, Equation (1) becomes

$$\frac{dV}{d\theta} = \frac{A\Delta P_f(1 - vC)^3}{\mu(W/A)kS_w^2C} \tag{2}$$

This permeability equation is valid only for conditions of viscous flow, and may be applied only to preformed beds that are at a uniform degree of compaction, i.e., to beds in which the porosity is uniform throughout.

The Kozeny-Carman relationship has been tested and confirmed over limited porosity ranges for a variety of materials including various powders, sands, glass spheres, wire crimps, and fibrous materials such as glass wool, cotton, rayon, textile wool, and wood pulp. Sullivan and Hertel (*22*) have summarized some of these investigations and have also given an analysis of the theoretical background of the Kozeny equation. Carman (*6*) has listed some of the limitations involved in application of the Kozeny equation to permeability investigations.

The material used in the experimental work in this study was cellulose fibers from a wood pulp. The air permeability of long fibrous materials such as glass wool, cotton, and textile wool, whose external surface area and effective specific volume could be determined accurately by means other than the Kozeny equation, has been studied by Fowler and Hertel (*9*) and Sullivan and Hertel (*21*). These workers concluded that the Kozeny constant had an average value of 5.55 for randomly packed fibrous beds and showed no apparent variation with porosity over a range of 0.55 to 0.86. Sullivan (*19, 20*) found the Kozeny constant increased with increasing void fractions at higher porosities. Brown's (*1*) air permeability data for wood pulps showed no apparent variation of the Kozeny constant over a porosity range of 0.45 to 0.91. His studies indicated that effective specific surface, specific volume, or the Kozeny constant may be functions of porosity at lower values of the void fraction.

Robertson and Mason (*16*) investigated the water permeability of wood pulps, and found the Kozeny-Carman equation was applicable over porosity ranges of about 0.40 to 0.85. At higher porosities an apparent increase in the Kozeny constant was noted for rayon and cotton fibers. In a later paper, Mason (*14*) reported observation of anomalies in the Kozeny-Carman relationship at lower porosities. Robertson and Mason emphasized the importance of Carman's (*6*) statement that, if the Kozeny equation is to be applied to porous beds, it is essential to avoid local variations in the degree of packing of the bed. Variations in porosity can arise from flocculation effects when the bed is formed, and subsequently from nonuniform compression during the permeability measurements.

Leva and co-workers (*13*) have noted that for nonporous solids the effective specific volume in the Kozeny equation can be determined pycnometrically. However, for porous solids, use of the specific volume determined by displacement techniques includes some or all of the internal particle voids that are presumably not available for fluid flow, and would lead to an excessive porosity value in permeability calculations. Thus, the effective specific volume of porous materials must be determined through use of the Kozeny or an equivalent equation. Robertson and Mason (*16*) have used a similar argument concerning the value of the effective specific volume for cellulose fibers used in water-permeability studies. They point out, that besides being a porous material, cellulose fibers swell in water, and since the dimensional swelling of the fibrous mass is not known, the void fraction cannot be obtained directly from the mass concentration of solids in the bed. These investigators arranged the terms of the Kozeny-Carman equation in such a manner that both the value of the product of the Kozeny constant and the square of the specific surface, kS_w^2, and the effective specific volume, v, could be determined by a graphical treatment of permeability data obtained at various values of pad concentrations. A similar method of plotting was used by Fowler and Hertel (*9*) in order to avoid any assumptions concerning the correct value of the effective specific volume for use in the Kozeny equation.

Nature of Filtration Resistance

It is desired to consider the possible application of Equation (2) to the dynamic case of a porous cake composed of compressible particles, in which the cake is formed under conditions of a constant-pressure filtration. The mechanical compacting (or compression) pressure, P_s, varies throughout the bed. At any given point in the bed it is equal to the frictional pressure drop past the particle at that point plus the cumulative frictional pressure drop resulting from all the particles behind it. Thus, the compressive effect increases with the depth of the cake and reaches a maximum at the septum surface ($P_s = \Delta P_f$). At the upstream face of the bed, the compacting pressure and the frictional pressure drop are equal to zero. Expressing this situation mathematically,

$$d(\Delta P_f) = dP_s \tag{3}$$

If the Kozeny-Carman equation is to be applied to such a bed, it must be written for a *differential* mass of the bed, dW, of uniform point concentration, C, over which the differential frictional drop is $d(\Delta P_f)$. The equation then may be written for the whole cake by separating the variables and integrating over the cake limits. Because the concentration, C, is more properly a function of compacting pressure, P_s, the substitution given in Equation (3), is also made, and Equation (2) becomes

$$\frac{dV}{d\theta} = \frac{A\displaystyle\int_o^{P_s}[(1 - vC)^3/C]dP_s}{\mu(W/A)kS_w^2} \tag{4}$$

The point concentration, C, must be expressed as a function of the compacting pressure, P_s, before the numerator of Equation (4) can be integrated in general terms. In arriving at Equation (4) the Kozeny constant, k, has been assumed to be independent of the porosity or void fraction, $\epsilon = 1 - vC$, over the range involved.

The usual filtration equation, based on a simplification of Poiseuille's law, may be written with the average specific filtration resistance, α, defined on a mass basis

$$\frac{dV}{d\theta} = \frac{A\Delta P_f}{\mu(W/A)\alpha} \tag{5}$$

From Equations (4) and (5) average specific resistance may be expressed as

$$\alpha = \frac{kS_w^2\Delta P_f}{\displaystyle\int_o^{P_s}[(1 - vC)^3/C]dP_s} \tag{6}$$

Method of Attack

The purpose of this study was to attempt to establish the validity of Equation (6) in which the average specific filtration resistance of a compressible bed is expressed in terms of the filtering pressure, and the specific surface, effective specific volume, and compressibility of the material in question. The following method of attack was used.

Filtration resistance may be determined as a function of frictional pressure drop from application of an integrated form of Equation (5) to constant-pressure filtration data. Filtration resistance at a given frictional pressure drop may also be calculated from Equation (6) if one has a measure of the product of the Kozeny constant and the square of the specific surface, kS_w^2, the effective specific volume, v, and knowledge of bed concentration, C, as a function of compacting pressure, P_s. Static studies with preformed beds may be used to evaluate these variables. Then a comparison of filtration resistances calculated from dynamic studies and static studies can be used to test the validity of Equation (6).

Obviously Equation (6) will not be applicable to a material or a porosity range for which the Kozeny-Carman permeability relationship, as given in Equation (2), does not hold. A combination of experimental conditions and ranges of variables were chosen for the constant-pressure filtrations, permeability studies, and the compressibility measurements, which would best fit the porosity values over which the Kozeny-Carman equation is known to be applicable to wood pulp fiber in water.

Experimental Equipment and Procedures

CONSTANT-PRESSURE FILTRATIONS

A single apparatus, shown schematically in Figure 1, was constructed to carry out constant-pressure filtrations, permeability runs, and compressibility measurements. The filtration tube was made of 3½-in. diam. Lucite with a constant-head section of 6 in. diam. The septum consisted of a 150-mesh screen backed by a 65-mesh screen on a perforated brass disk. The pressure drop across the septum was found to be negligible in comparison with the pressure drops used across the pulp pads in all the experiments. Frictional pressure drops of from zero to 90 cm. of water could be applied across pulp pads by adjusting the height of the discharge chamber in the suction leg line. The suction leg was made of ⅞-in. diam. polystyrene flanged tubes, each section of which was about 12 in. long.

Water at a constant temperature and free of air bubbles for use in static and dynamic studies was obtained by mixing filtered steam and filtered water. The tap water used in the experiments contained about 100 p.p.m. of dissolved solids. A special filtration showed no significant difference in the calculated filtration resistances using distilled water and tap water. Temperature, in the range of 10 to 40° C., was found to have no effect on specific filtration resistance.

The experimental work was carried out with an unbeaten pulp and a moderately beaten pulp refined in a laboratory Valley beater. These pulps were prepared from a batch of West Coast coniferous bleached sulfite air-dry laps.

The procedure for carrying out a constant-pressure filtration was to add the deaerated pulp slurry to a gravity feed tank which contained the proper amount of water at 30° C. to give a final prefilt concentration of 0.01%. Agitation of the slurry in the feed tank was accomplished by means of Lightnin' mixers. A constant level of slurry was maintained in the filtration tube by means of an adjustable clamp on a rubber tubing feed line. The frictional pressure drop expressed as centimeters of water was taken as the difference in liquid levels in the constant-head tube and in the manometer, plus the manometer capillary correction. To attain a high degree of precision in taking time-volume data, the filtrate volumes measured in graduated cylinders were recorded by a magnetic tape recorder, and later measured as a function of time by playing back the recorded data and determining the time increments with electric timers reading to 0.1 sec.

To avoid flocculation effects it was necessary to use a combination of relatively dilute prefilt concentration and agitation of the pulp slurry in the constant-head tube. A standard prefilt concentration of 0.01% was selected after making a number of trial filtrations. At concentration values appreciably in excess of 0.01%, large fiber flocs were observed to form in the filtration tube, and the amount of agitation required to disperse the fiber flocs was so great that considerable turbulence resulted at the pad face. This turbulence disturbed the pad formation, and nondispersed flocs resulted in heterogeneous pad formation. The agitation device was a variable-speed stirrer equipped with an L-shaped glass rod and mounted off-center in the constant-head tube.

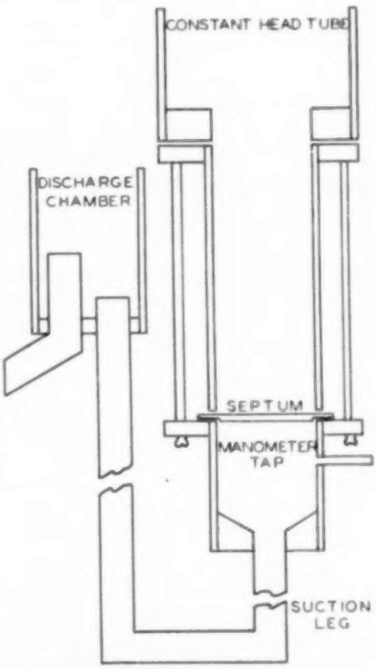

Fig. 1. Filtration and permeability apparatus.

At a prefilt concentration of 0.01%, the initial filtration flow rates were in the turbulent range, and it was necessary to open the cock valve gradually at the beginning of a filtration to maintain a constant liquid level in the constant-head tube. When allowance for the resulting initial variation in frictional pressure drop, ΔP_f, and average specific resistance, α, is made in the integration of the filtration rate equation, Equation (5), it can be shown that

$$\frac{(\theta - \theta_1)}{(V - V_1)} = (\mu c \alpha / 2A^2 \Delta P_f)(V + V_1) = B\alpha(V + V_1) \tag{7}$$

where the values of θ_1 and V_1 are those that correspond to the attainment of the desired value of ΔP_f. Average specific filtration resistance, α, was determined from the slope of a $(\theta - \theta_1)/(V - V_1)$ vs. $(V + V_1)$ or V plot, and the experimental value of the filtration constant, B. The mass of fibers in the pulp pad per unit volume of filtrate, c, was calculated from a knowledge of the ovendry pad weight and the equivalent filtrate volume.

COMPRESSIBILITY MEASUREMENTS

Wet pad compressibility measurements were taken over a compacting pressure range of 10 to 100 g./sq.cm., using a screen piston similar in design to the septum. The lower pressure limit was fixed by the weight of the unloaded piston assembly. Pad thicknesses were measured with a cathetometer, and compacting pressure values were calculated from the known loads on the piston rod and the weight of the piston assembly (corrected for water displacement). The data were used to calculate the pad concentration, C, as an empirical function of the compacting pressure, P_s.

PERMEABILITY STUDIES

The screen piston was used also in the static studies to compress pulp pads to desired concentration values. An adjusting nut was used to fix the vertical position of the permeable piston and to prevent continued compression of the pulp pad during flow rate measurements. In general, the procedures established by Robertson and Mason (16) were used in the studies with preformed beds. Equation (2) may be written as

$$\left(\frac{C}{\alpha_p}\right)^{1/2} = \left(\frac{1}{kS_w^2}\right)^{1/2}(1 - vC) \tag{8}$$

where α_p, the specific permeation resistance of a preformed and uniform bed, is calculated from the relationship

$$\frac{dV}{d\theta} = \frac{A \Delta P_f}{\mu (W/A) \alpha_p} \tag{9}$$

Flow rate, pressure drop, water temperature, and pad thickness were measured at different

values of increasing pad concentration. The data were used to calculate the product of the Kozeny constant and the square of the specific surface, kS_w^2, and the effective specific volume, v by the application of Equation (8).

If the left-hand member of Equation (8) is plotted against pad concentration, C, a straight line will result if kS_w^2 and v do not vary with porosity over the range in question. The slope and intercept of the graph may be used to evaluate kS_w^2 and v.

Experimental Results

CONSTANT-PRESSURE FILTRATIONS

The results of the constant-pressure filtrations are given in Table 1. The data show that the average specific resistance of compressible pulp pads is a marked function of the frictional pressure drop across the pad. An example of a filtration plot is shown in Figure 2 and is representative of the precision that was attained in taking filtration data. The filtration curves were not extrapolated below filtrate volumes equal to V_1, since interpretation of the zero volume intercepts was obscured because of the initial variation in pressure drop and filtration resistance, and complications of turbulent flow.

The unbeaten pulp had a constant value of average specific resistance over a large volume range, but all the beaten pulp filtrations showed increasing filtration resistance after the run had proceeded for a considerable length of time. Because a beaten pulp contains considerably more fines and fiber fragments than does an unbeaten pulp, it is believed that this increase in average specific resistance is probably attributable to the partial movement of fines and fiber debris in the pulp pad with continued flow. Slope determinations in the graphical treatment of the beaten pulp filtrations were made over the initial and intermediate stages of the runs,—i.e., in a range where no increase in filtration resistance occurred.

PERMEABILITY STUDIES

Because of the increase in filtration resistance which was found in the filtration studies on a beaten pulp, it was necessary to form beaten pulp pads for static studies from slurries at 0.4% concentration. Unbeaten pulp pads were formed at 0.05% concentration with no decay in permeability in evidence. While forming the pads, it was necessary to provide manual stirring as well as stirring in the constant-head tube to prevent gross flocculation near the pad face. These stirring operations were found to be quite critical, and considerable practice was required before homogeneous pads could be formed at these high slurry concentrations.

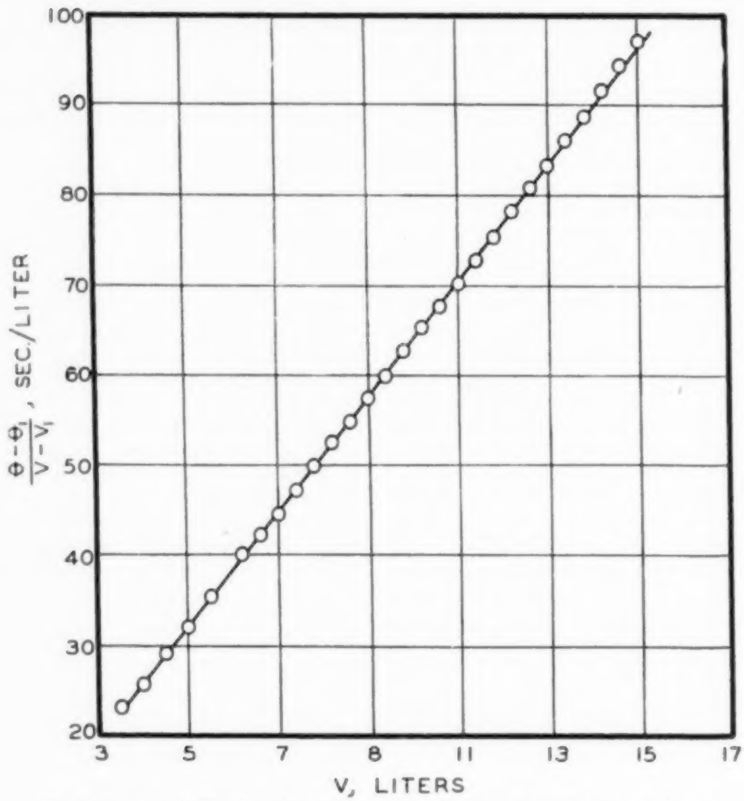

Fig. 2. Beaten pulp filtration at constant pressure of 10 cm. of water, concentration of 0.01%, and at 30° C.

Table 1.—Constant-Pressure Filtrations

Frictional Pressure Drop, $\Delta P_f/\rho g$, cm. of water	Temperature, °C.	Consistency, g./cc. $\times 10^5$	Filtration Constant, $B = \mu c/2A^2\Delta P_f$, c.g.s. units $\times 10^{14}$	Slope of Filtration Graph, $B\alpha$, c.g.s. units $\times 10^6$	Specific Filtration Resistance, α, cm./g. $\times 10^{-8}$	Avg. of Filtration Resistance, α, cm./g. $\times 10^{-8}$	Avg. Deviation of Filtration Resistance from the mean, %
			Beaten Pulp[1]				
1	30.0	9.33	15.63	19.73	1.263	1.28	1.3
	30.2	9.86	16.43	21.30	1.296		
10	29.3	9.46	1.608	6.82	4.24	4.12	2.9
	30.2	9.48	1.580	6.32	4.00		
30	29.5	9.45	0.533	4.24	7.95	7.90	0.6
	29.8	9.53	0.534	4.19	7.85		
50	29.3	9.41	0.320	3.52	11.00	10.82	1.7
	30.1	9.46	0.316	3.36	10.63		
70	29.8	9.49	0.228	3.09	13.58	13.36	1.7
	29.8	9.57	0.230	3.02	13.13		
90	30.1	9.53	0.177	2.94	16.62	16.55	1.4
	30.15	9.56	0.178	2.92	16.48		
							Avg. 1.6
			Unbeaten Pulp[2]				
1	29.45	9.60	16.60	2.00	0.120		
10	28.95	9.74	1.668	0.502	0.301		
30	29.8	9.79	0.548	0.284	0.519		
50	30.0	9.80	0.328	0.220	0.671		
70	30.0	9.80	0.234	0.190	0.809		
90	29.9	9.79	0.183	0.174	0.951		

[1] Schopper-Riegler freeness, 620 cc.
[2] Schopper-Riegler freeness, 880 cc.

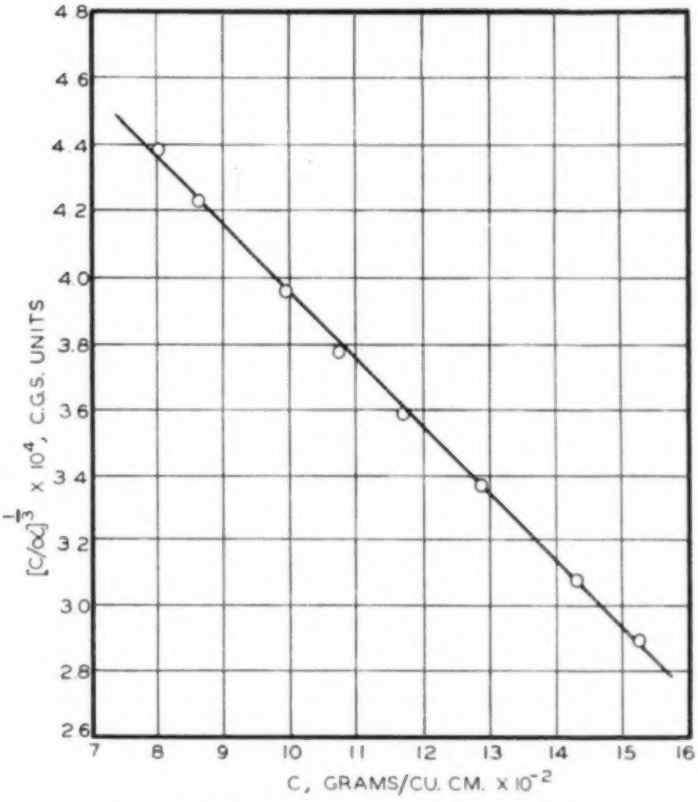

Fig. 3. Rectified Kozeny-Carman equation plot, beaten pulp.

Table 2.—Specific Surface and Effective Specific Volume

Pulp	Calculated from Permeability Data[1] $kS_w^2 \times 10^{-8}$, c.g.s. units	S_w, sq.cm./g.	v, cc./g.	Calculated from Filtration Data[2] S_w, sq.cm./g.	v, cc./g.	Silvering Method[3] S_w, sq.cm./g.
Beaten	47.15	29,200	3.40	29,200	3.41	14,400
Unbeaten	4.345	8,860	2.21	8,330	2.43	8,700

[1] Average of four determinations for beaten pulp and two determinations for unbeaten pulp. Specific surfaces based on a value of 5.55 for the Kozeny constant (9).

[2] Calculated from average specific filtration resistance values at 10 and 50 cm. of water pressure drop.

[3] Determinations made by analytical department, The Institute of Paper Chemistry (2).

Table 3.—Permeability Study Calculation

(Beaten Pulp)

Flow Rate, $dV/d\theta$, cc./sec.	Frictional Pressure Drop, $\Delta P_f/\rho g$, cm. of water	Frictional Pressure Drop, ΔP_f, dynes/sq.cm. $\times 10^{-3}$	Bed Thickness, L, cm.	Pad Concentration,* C, g./cc.	Viscosity, μ, cp.	Permeation Resistance, α_p, cm./g. $\times 10^{-8}$	$(C/\alpha_p)^{1/3}$, c.g.s. units $\times 10^4$
0.1283	8.00	7.80	5.01	0.0805	0.784	9.50	4.39
0.1209	9.10	8.875	4.665	0.0865	0.787	11.43	4.23
0.1773	18.75	18.30	4.045	0.0997	0.789	16.03	3.96
0.1920	25.12	24.55	3.75	0.1075	0.789	19.86	3.78
0.2400	40.15	39.15	3.445	0.1172	0.790	25.35	3.59
0.1795	40.15	39.15	3.13	0.1288	0.796	33.6	3.37
0.1711	55.40	54.0	2.82	0.1432	0.789	49.0	3.08
0.1338	55.40	54.0	2.645	0.1525	0.790	62.6	2.90

* Ovendry pad weight, W = 19.985 grams; bed area, A = 49.5 sq.cm.

The calculated results from the static permeability determinations on preformed pads are given in Table 2. The graphical data for the rectified Kozeny-Carman equation are shown in Figure 3 as being typical of all the static runs in regard to the deviation of the experimental points from the linear relationship predicted by Equation (8). A sample calculation for the test shown in Figure 3 is given in Table 3. Pad concentrations lower than about 0.08 g./cc. were not studied since the frictional pressure drops necessary to give measurable amounts of flow tended to compress the pad and give nonuniform porosities.

Values of the specific surface and effective specific volume obtained for the two pulps are of the same order of magnitude as those reported by Robertson and Mason (*16*) for similar bleached sulfite pulps using a water permeability technique. Robertson and Mason noted that the effective specific volumes for wood pulps, even when corrected for the contribution of fiber voids, represent an abnormally high degree of swelling. These authors point out that the effective specific volume represents the hydrodynamic volume per unit mass of material, i.e., the volume denied to the flowing liquid, and that a portion of the abnormally high v value for pulps might be attributed to the action of fibrils which may immobilize a portion of the liquid and thus contribute to the specific volume.

As an independent check on the values for specific surface of fibers in the water-swollen state, this property was also measured by a surface catalytic method (*2*). This technique is based on a measurement of the catalytic activity of a silvered fiber surface in decomposing hydrogen peroxide under standardized conditions. Good agreement is shown in Table 2 for the specific surface values of the unbeaten pulp measured by permeability and silvering methods. However, the water permeability technique gave a much higher S_w value for the beaten pulp than did the silvering method. Browning (*2*) and Mason (*11*) have commented on the tendency for fines in some beaten pulps to lead to experimental difficulties in the silvering method that yield spuriously low specific surface values.

COMPRESSIBILITY MEASUREMENTS

Wet pulp pad concentration values as a function of compacting pressure could be represented with good precision by the empirical relationship

$$C = MP_s^N \tag{10}$$

where M and N are constants. An example of one set of data is shown graphically in Figure 4, and the compressibility constants are given in Table 4.

Table 4.—Compressibility Constants For Empirical Relationship, $C = MP_s^N$

Pulp	Test	M	N
Beaten	A	0.00400	0.321
	B	0.00412	0.318
Unbeaten		0.00421	0.315
	Avg.	0.00411	0.318

Campbell (3) found a similar compressibility function for a kraft and a groundwood pulp, and also showed that the compressibility constants were apparently unaffected by beating. However, when a wet pulp pad is compressed, it is not only the fibrous portion of the pad that resists the compacting force, but also any water that is absorbed by the fibers and any water immobilized by fibrils. Hence, in comparing the compressibility functions of the unbeaten and beaten pulps, it would be more fundamental to express the pad concentration in terms of the solid fraction, vC. Using this concept of compressibility, Equation (10) becomes $vC = vMP_s^N$. Since the effective specific volume is 2.21 for the unbeaten pulp and 3.40 for the beaten pulp, the latter pulp may be considered the more compressible by the ratio of the two v values.

Equation (10) implies that the pad concentration at zero compacting pressure is zero. This is not strictly true, but is regarded as a good approximation for the case of wet beds of pulp fibers. Measurements were taken of different filter beds after they had been allowed to expand for 24 hr. at the end of the filtrations. This zero pressure concentration depended upon the value of the frictional pressure drop used in the filtrations—zero pressure pad concentration increasing with increasing pressure drop characteristic of the filtration. The beds formed from the lowest pressure-drop filtrations (1 cm. of water) gave expanded pad concentrations of about 0.007 g./cc. which corresponded to a porosity ($\epsilon = 1 - vC$) of approximately 0.99. Recognizing that the true zero pressure porosity was greater than this value, a pad concentration of zero was assumed for zero compacting pressure.

CALCULATION OF FILTRATION RESISTANCE FROM AN INTEGRATED KOZENY-CARMAN EQUATION

Recalling Equation (6),

$$\alpha = \frac{kS_w^2 \Delta P_f}{\int_0^{P_s} [(1 - vC)^3/C]\, dP_s} \qquad (6)$$

an expression for the average specific resistance as a function of frictional pressure drop may be obtained by expressing the pad concentration, C, as a function of the compacting pressure, P_s, using the compressibility function given by Equation (10). Carrying out the integration and making the substitution, $P_s = \Delta P_f$ gives Equation (11) ►

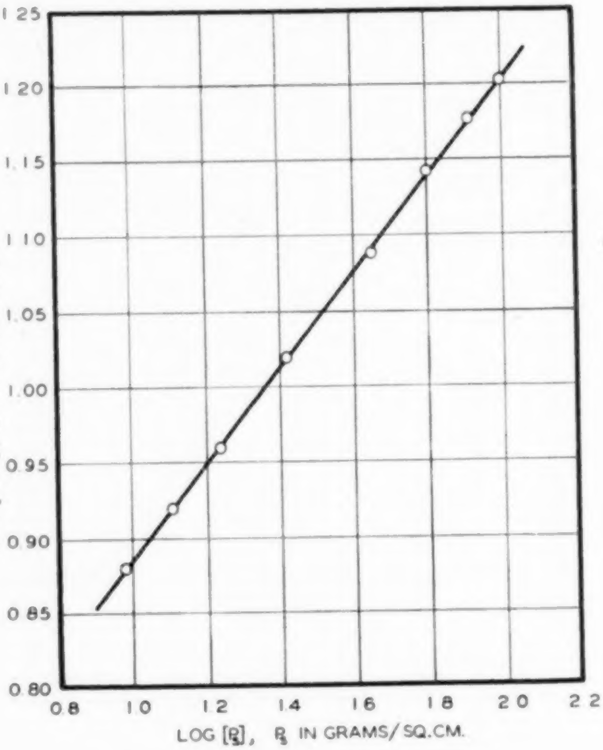

Fig. 4. Wet pulp pad compressibility, beaten pulp.

Table 5.—Comparison of Filtration Resistance Calculated From Dynamic and Static Study Data

Frictional Pressure Drop, $\Delta P_f/\rho g$, cm. of water	Filtration Resistance; α, Calculated from Constant-Pressure Filtration Data (Table I), cm./g. × 10^{-8}	Filtration Resistance, α, Calculated from Integrated Kozeny-Carman Relationship (Eq. 11), cm./g. × 10^{-8}	Deviation of Static Values from Dynamic Results, %	Minimum Bed Porosity,* ε
		Beaten Pulp		
1	1.28	1.54	20.1	0.867
10	4.12	4.34	5.3	0.739
30	7.90	8.02	1.5	0.632
50	10.82	11.10	3.0	0.567
70	13.36	14.03	5.0	0.517
90	16.55	16.85	1.8	0.477
			Avg. 6.1	
		Unbeaten Pulp		
1	0.120	0.133	10.8	0.913
10	0.301	0.325	8.0	0.830
30	0.519	0.543	4.6	0.761
50	0.671	0.706	5.1	0.718
70	0.809	0.847	4.7	0.686
90	0.951	0.980	3.1	0.660
			Avg. 6.0	

* $\epsilon = 1 - vC$, minimum ε calculated from point concentration, C, at bed face adjacent to septum. Maximum porosity, at upstream pad face, has been taken as unity in all cases.

$$\alpha = \frac{kS_w^2}{\frac{1}{(M\Delta P_f^N)(1-N)} - 3v + \frac{3v^2(M\Delta P_f^N)}{(1+N)} - \frac{v^3(M\Delta P_f^N)^2}{(1+2N)}} \tag{11}$$

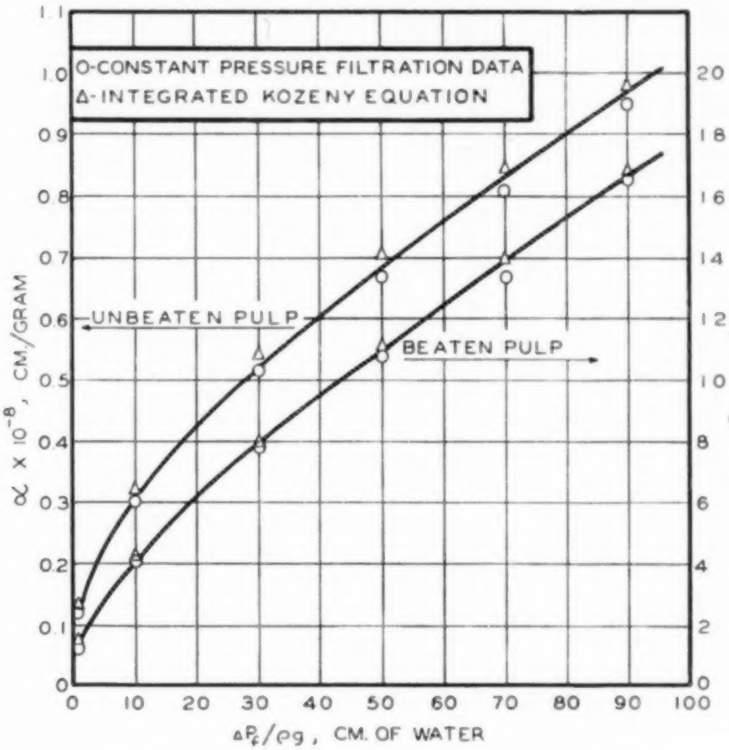

Fig. 5. Filtration resistance as a function of frictional pressure drop.

Equation (11) may be used to calculate average specific resistance as a function of the frictional pressure drop in a constant-pressure filtration from a knowledge of the physical properties of the material composing the bed. Using the previously determined values of kS_w^2, v, M, and N, the results of such calculations are compared in Table 5 with the average specific resistance as measured in actual constant-pressure filtrations. Filtration resistances are shown as a function of frictional pressure drop in Figure 5.

The average deviation of all the values calculated from the integrated form of the Kozeny-Carman equation of α from the constant-pressure filtration values was 6%. Inspection of Table 5 shows that this average, especially in the case of the beaten pulp, was unduly influenced by the deviation for the filtrations at 1 cm. of water frictional pressure drop. Porosities for these filtrations were in the high range of void fractions of from 0.9 to approximately unity where the Kozeny constant might have been variable (*16, 20, 22*), and where pad compressibility relationships depend upon extrapolated data. Also, the precision of the low frictional pressure-drop value of 1 cm. of water was probably not greater than 10%, since these readings were made with a possible error of ± 1 mm. of water. However, the postulation that the Kozeny constant increases with increasing porosity in this range, or that the zero pressure pad concentration should have a finite value, would mean that the filtration resistances calculated from Equation (11) should be lower than those derived from constant-pressure filtration data. The data of Table 5 show the opposite effect. It is probable that the differences between the dynamic and static study data are attributable to experimental errors which are magnified through use of Equation (11), and may overshadow possible variations in the Kozeny constant or errors involved in the assumption of zero filtration resistance at a frictional pressure drop of zero. In any event, the data represented in Table 5 are regarded as substantial experimental proof that the filtration resistance of the compressible pulp beds may be expressed in terms of the filtering pressure and the properties of the particles composing the filter bed.

Equation (6) or (11) defines the nature of the curve obtained by plotting average specific resistance against frictional pressure drop (Fig. 5) in constant-pressure filtrations over a range of pressure drops in which a definite compressibility function exists. This curve must be one with a continually decreasing slope, although it may appear to be linear over a small range of frictional pressure drop. This fact is not in agreement with the parabolic curve of increasing slope obtained by Collicutt (*7*) in his constant-pressure filtrations of groundwood pulps. However, as Collicutt pointed out, his work was complicated by the problem of agitation in the relatively high prefilt concentration range of 0.15 to 0.3%. This flocculation effect may in part explain the difference between Collicutt's results for α as a function of ΔP_f, and the findings of this study.

Average specific resistance is sometimes expressed as an empirical function of the frictional pressure drop, i.e., α is proportional to ΔP_f raised to a fractional exponent that varies from zero for a completely rigid cake to unity for a cake of maximum compressibility. Carman (*5*) has observed that this type of empirical relationship has been of practical usefulness in representing data with sufficient accuracy for some engineering purposes, but that it only roughly expresses experimental data. Mathematical verification of this statement may be seen from examination of Equation (6) or (11). A logarithmic plot in Figure 6 of α as a function of ΔP_f for the constant-pressure filtrations of this study shows the relationship $\alpha = \alpha' \Delta P_f^n$ to be an approximate representation of the data. The compressibility coefficient, n, is 0.47 for the unbeaten pulp and 0.60 for the beaten pulp.

When one deals with a noncompressible material, Equation (6) becomes

$$\alpha = \frac{kS_w^2 C}{(1 - vC)^3} \tag{12}$$

This relationship has been verified by Hoffing and Lockhart (*11*) for the essentially rigid mixtures of quartz and diatomaceous earth.

Average specific resistance is sometimes defined on a volume basis, α_v, where

$$\alpha_v = C_{avg}\alpha \tag{13}$$

C_{avg} is an average value for the concentration of particles in a filter bed and is given by

$$C_{avg} = W/AL \tag{14}$$

where L is the filter bed length at any given time. It can be shown that

$$\alpha_v = \frac{kS_w^2 \Delta P_f}{\int_0^{P_s} [(1 - vC)^3/C^2]\, dP_s} \tag{15}$$

This relationship is nearly the same as that given for average specific resistance on a mass basis in Equation (6), the exception being that the pad concentration, C, is squared in the denominator of the α_v porosity function whereas it appears only to the first power for α. Hence, α_v is more sensitively dependent upon the pad compressibility than is α. There is no advantage to be gained in defining filtration resistance on a volume basis, but rather there is the serious disadvantage of having to determine an addi-

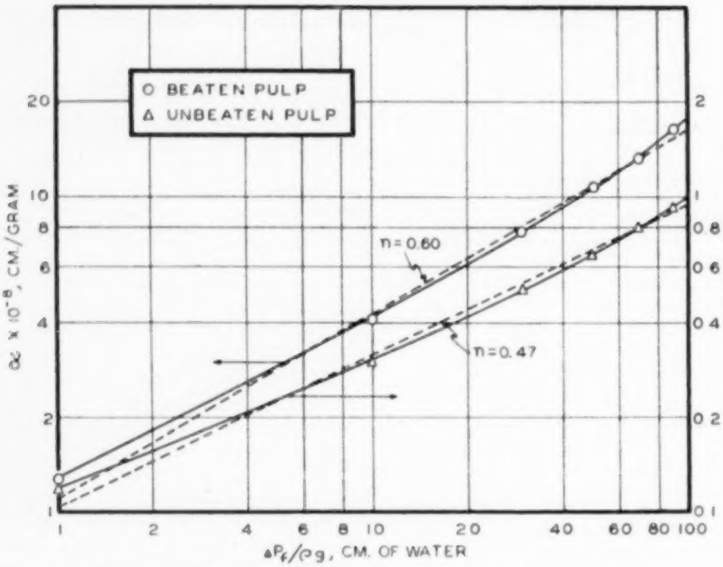

Fig. 6. Logarithmic plot, filtration resistance vs. frictional pressure drop.

tional experimental value, C_{avg}, which in many cases is difficult to measure with ease, precision, or accuracy. Definition of filtration resistance on a mass instead of a volume basis should be a preferred procedure, at least in the case of compressible materials.

Preformed bed studies are hindered in some instances by a decay in permeability with continued flow. In some cases, the effect of this phenomenon can be minimized by a technique of flow reversals (*16*). When a decay in permeability limits the lower range of slurry concentrations from which pads of adequate thicknesses can be formed, it often leads to flocculation effects with resulting nonuniformity of pads and spuriously high permeability values. These difficulties may be overcome by calculating specific surface and effective specific volume values from the results of two constant-pressure filtrations and a compressibility measurement. Average specific filtration resistance, defined on a mass basis, can be determined for thin pads of nonmeasurable thicknesses, through which the total volume of flow has been small enough not to give rise to a decay of permeability. The only limiting factor for prefilt concentration and flow time is that the flow must be laminar.

For example, arbitrarily taking the filtration resistances determined at frictional pressure drops of 10 and 50 cm. of water, and using the compressibility data given in Table 4, Equation (11) may be written as two simultaneous equations which can be solved for the two unknowns—specific surface and effective specific volume. The values of S_w and v calculated in this manner and shown in Table 2 compare favorably with the static study results. The calculation of specific surface and effective specific volume from dynamic data may also be useful in cases where the permeability of preformed beds is too low to yield measurable volumes of flow over the necessary pad concentration range.

Notation

A = cross-sectional area of porous bed, sq.cm. (49.5 sq.cm. for septum)

B = constant for a given constant-pressure filtration, $B = \mu c/2A^2\Delta P_f$, c.g.s. units

C = mass of fibers per unit volume of a uniform bed, g./cc.

c = mass of fibers in a filter bed per unit volume of filtrate, g./cc.

g = acceleration caused by gravity, 980 cm./(sec.)(sec.)

k = Kozeny constant, dimensionless

L = bed thickness, cm.

M, N = empirical constants in compressibility function, $C = M\Delta P_s^N$

n = compressibility coefficient in empirical relationship, $\alpha = \alpha'(\Delta P_f)^n$

P_s = mechanical compacting pressure, dynes/sq.cm.

ΔP_f = frictional pressure drop across a uniform or a filter bed, dynes/sq.cm.

S_o = specific surface of bed material, volume basis, sq.cm./cc.

S_w = specific surface of bed material, mass basis, sq.cm./g.

V = filtrate volume at time, θ, cc.

v = effective specific volume of bed material, cc./g.

W = mass of fibers in a uniform bed or in a filter bed at time θ, g.

α = average specific resistance of a filter bed, mass basis, cm./g.

α' = proportionality factor in the relationship, $\alpha = \alpha'(\Delta P_f)^n$

α_p = specific permeation resistance of a uniform bed, mass basis, cm./g.

α_v = average specific resistance of a filter bed, volume basis, cm.$^{-2}$

ϵ = porosity of a uniform bed, void volume per bed volume, dimensionless

θ = time of filtration, sec.

μ = viscosity of filtrate, poises

ρ = density of filtrate, g./cc.

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Contact-Process Converter Design

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A new equation for the rate of oxidation of sulfur dioxide with a vanadium catalyst preparation is employed in order to determine the amounts of catalyst required for a given duty. This has been done for the particular case of a two-stage adiabatic converter system, although the extension of the method to multi-stage adiabatic systems is obvious.

The temperature distribution for a converter fitted with heat-exchangers which will ensure a maximum reaction rate at all points and a minimum size of the equipment, has also been calculated from the kinetic equation.

The calculated optimum temperature distribution does not differ greatly from that found in some commercial converters fitted with heat-exchangers.

The economy in size and amounts of catalyst realized by using such an optimum temperature distribution is seen to be considerable.

A study was recently made of the kinetics of the oxidation of sulfur dioxide with a commercial catalyst preparation (*1*). This preparation, consisting of vanadium oxide supported on silica gel has been described by Maxted (*7*).

A flow-type isothermal reactor with precise temperature control was employed in the investigation and an extremely sensitive analytical technique was developed.

It was found that the rate of the forward reaction

$$SO_2 + \tfrac{1}{2}\, O_2 \rightarrow SO_3$$

was expressible by means of the following equation. (*See* Table 1.)

$$r = k_1 \cdot P_{SO_2}{}^{0.4} \cdot P_{O_2}{}^{0.8}$$

Previously published work, notably by Russian workers (*5*) on the kinetics of the oxidation of SO_2 using commercial vanadium catalysts proposes the rate equations

$$r_1 = k_1 \cdot P_{SO_2}{}^{0.8} \cdot P_{O_2}{}^{1.0} \qquad (2)$$

$$r_1 = k_1 \cdot P_{SO_2}{}^{0.5} \cdot P_{O_2}{}^{1.0} \qquad (3)$$

Unfortunately, insufficient detail is given to enable one to judge the accuracy of this work.

Parallel studies (*1*) on the adsorption of O_2 and SO_2 on the catalyst showed that SO_2 is strongly chemisorbed with a heat of adsorption of 28.8 *K*cal. at a rate far greater than the observed rate of reaction. Oxygen, on the other hand, is weakly adsorbed by a Van der Waals type of adsorption involving only 6.4 *K*cal. at a much slower rate than the rate of reaction.

It seems certain, from the adsorption studies considered in conjunction with the form of the rate equation, that the rate-determining step in the oxidation of SO_2 is the rate of oxidation of chemisorbed SO_2 by oxygen in the gas phase.

The reaction mechanism proposed is consequently

$$\underset{\text{gas}}{SO_2} + \underset{\text{active centers}}{2e} \rightleftharpoons \underset{\text{chemisorbed complex}}{SO_2{}^{--}}$$

$$\Delta H = -28.8\ K\text{cal./mole} \qquad (4)$$

(Fast chemisorption of SO_2)

$$O_2 + SO_2{}^{--} \rightleftharpoons SO_3 + O^{--} \qquad (5)$$

(Slow 2nd order reaction)

Table 1.—Reaction Rates

(moles SO_2 converted/(g. catalyst)(sec.) × 10^7 in range of conversion (0-10)%

Gas Composition

Temp. °C.	$P_{SO_2} = 0.167$ atm. $P_{O_2} = 0.180$ atm. $P_{N_2} = 0.668$ atm.	$P_{SO_2} = 0.800$ atm. $P_{O_2} = 0.040$ atm. $P_{N_2} = 0.160$ atm.	$P_{SO_2} = 0.167$ atm. $P_{O_2} = 0.040$ atm. $P_{N_2} = 0.793$ atm.	(r in moles SO_2 converted/(g. catalyst)(sec.) (P in atm.)
370	7.06	4.10	2.36	$r_{370°C.} = 60 \times 10^{-7} \cdot P_{SO_2}{}^{0.85} \cdot P_{O_2}{}^{0.75}$
380	10.3	6.50	3.27	$r_{380°C.} = 88 \times 10^{-7} \cdot P_{SO_2}{}^{0.66} \cdot P_{O_2}{}^{0.77}$
390	15.5	10.0	5.22	$r_{390°C.} = 137 \times 10^{-7} \cdot P_{SO_2}{}^{0.62} \cdot P_{O_2}{}^{0.72}$
400	21.4	13.2	6.61	$r_{400°C.} = 180 \times 10^{-7} \cdot P_{SO_2}{}^{0.64} \cdot P_{O_2}{}^{0.78}$
410	28.8	19.2	8.04	$r_{410°C.} = 242 \times 10^{-7} \cdot P_{SO_2}{}^{0.58} \cdot P_{O_2}{}^{0.85}$
420	....	25.0	11.5	$r_{420°C.} = 334 \times 10^{-7} \cdot P_{SO_2}{}^{0.49} \cdot P_{O_2}{}^{0.80}$
430	....	33.3	17.5	$r_{430°C.} = 475 \times 10^{-7} \cdot P_{SO_2}{}^{0.43} \cdot P_{O_2}{}^{0.80}$

$$0^{--} \rightleftharpoons \tfrac{1}{2}O_2 + 2e \quad \Delta H = 6.4 \text{ Kcal/mole} \quad \text{(Fast desorption)} \qquad (6)$$

From Equation (5) the rate of the forward reaction is given by the expression

$$r = k'_1 a_{SO_2} P_{O_2} \qquad (7)$$

where a_{SO_2} is the concentration of adsorbed SO_2.

The aforementioned adsorption measurements showed that a_{SO_2} is proportional to $P_{SO_2}{}^{0.4}$ so that the rate equation becomes

$$r = k_1 \cdot P_{SO_2}{}^{0.4} \cdot P_{O_2}, \qquad (8)$$

in reasonable agreement with the observed expression of

$$r = k_1 \cdot P_{SO_2}{}^{0.4} \cdot P_{O_2}{}^{0.8}$$

For design purposes the data are sufficiently well expressed as follows:

$$r = k_1 \cdot P_{SO_2}{}^{1/2} \cdot P_{O_2}$$

for the forward reaction, giving for the rate of the over-all reaction

$$r = \frac{k_1 \cdot P_{SO_2} \cdot P_{O_2}}{P_{SO_2}{}^{1/2}} - \frac{k_2 \cdot P_{SO_3} \cdot P_{O_2}{}^{1/2}}{P_{SO_2}{}^{1/2}} \qquad (9)$$

where in the Langmuir-Hinshelwood ininterpretation $1/P_{SO_2}{}^{1/2}$ is an empirical expression proportional to the amount of free catalytic surface (*2*), indicating that O_2 and SO_3 are not appreciably adsorbed while SO_2 is strongly adsorbed.

In Figure 1, the reaction velocity constant for the forward reaction (k_1) has been plotted as a function of temperature in the Arrhenius form and the energy of activation (A_1) determined as 31 *K*cal. From the known heat of reaction (22.6 *K*cal.) the energy of activation for the reverse reaction follows, since

$$\Delta H = A_2 - A_1$$

whence $A_2 = 53.6$ *K*cal.

From Figure 1

$$\ln k_1 = \frac{-31{,}000}{RT} + 12.07 \qquad (10)$$

and since

$$\ln k_1 - \ln k_2 = \ln K_p = \frac{22{,}600}{RT} - 10.68$$

where K_p is the equilibrium constant (*6*)

$$\ln k_2 = -\frac{53{,}600}{RT} + 22.75 \qquad (11)$$

The final expression for the rate of oxidation of SO_2 in moles SO_2 con-

Table 2.—Reaction Rates

Range of Conversion, 80-100%

Reaction Rate in Moles SO_2 converted/(g. catalyst)(sec.)

Temp. ° C.	From B.I.O.S. Report No. 1623	Calculated from Equation (12).
380	7×10^{-8}	13×10^{-8}
390	29×10^{-8}	21×10^{-8}
400	31×10^{-8}	24×10^{-8}
410	31×10^{-8}	32×10^{-8}
	28×10^{-8}	32×10^{-8}
	28×10^{-8}	36×10^{-8}
	33×10^{-6}	32×10^{-8}
	21×10^{-8}	36×10^{-8}

Table 3.—Coefficients of Reaction Rate/10° C.

Temp. ° C.	(400-425)	(425-450)	(450-475)	(475-500)	(500-525)
Calculated coefficients	1.33	1.31	1.28	1.26	1.25
Grosvenor (Selden)	2.15	1.34	1.22	1.10	....
Grosvenor (Calco)	2.22	1.88	1.28	1.19	1.18
Maxted (Tin Vanadate)	1.3	1.9	1.49	1.34	1.25
Grosvenor (Vanadium on Pumice)	....	....	(1.52-1.85)	(1.04-1.67)	....

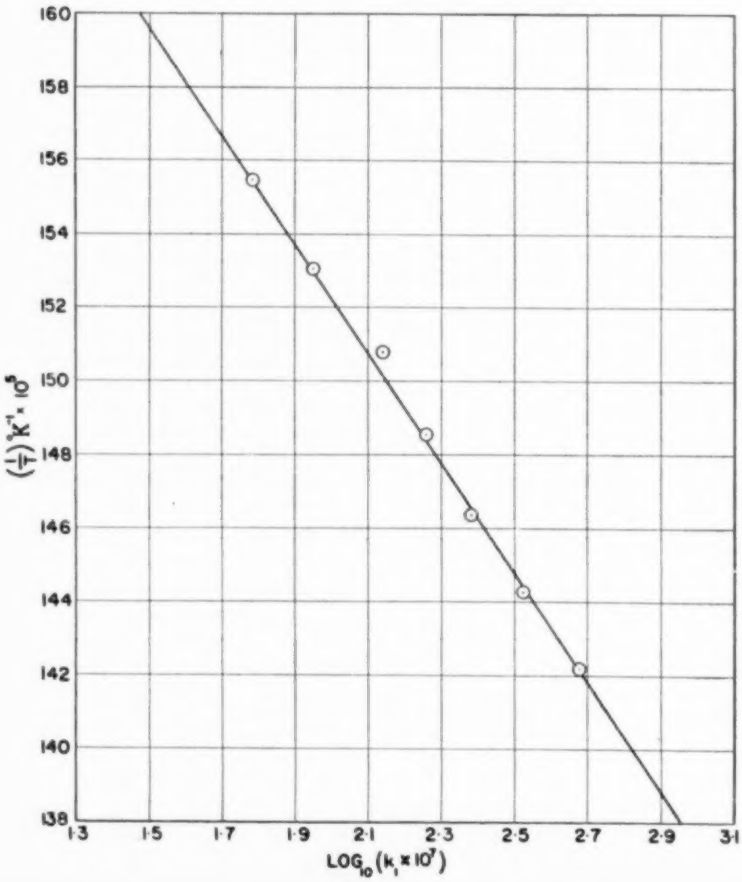

Fig. 1. Determination of the energy of activation for $SO_2 + \tfrac{1}{2}O_2 \rightarrow SO_3$.

verted/(g. catalyst.)(sec.) is therefore

$$r = \left(e^{\frac{-31{,}000}{RT} + 12.07} \right) \cdot \frac{P_{O_2} \cdot P_{SO_2}}{P_{SO_2}{}^{1/2}} - \left(e^{\frac{-53{,}600}{RT} + 22.75} \right) \cdot \frac{P_{SO_3} \cdot P_{O_2}{}^{1/2}}{P_{SO_2}{}^{1/2}} \quad (12)$$

These units may be converted into tons H_2SO_4 produced (ton catalyst) (day) by multiplying the above expression by 8.5×10^6, partial pressures being expressed as before in atmospheres. This equation was developed from measurements made at conversions up to 10% under strictly isothermal conditions but has proved satisfactory when tested up to 50% conversion under near-isothermal conditions.

Further evidence that the equation is applicable up to 100% conversion for a whole variety of commercial vanadium catalysts is obtained when a study is made of B.I.O.S. report No. 1623. In this report a number of German commercial vanadium catalysts were tested under near-isothermal conditions in the range of conversion (80%-100%). The report states that the results differ little from those obtained with British and American catalysts and that the amount of vandaium present in the catalyst has little effect on its activity, although it does affect its useful life.

In Table 2, the B.I.O.S. report data of feed composition, loading, conversion, temperature have for the purposes of comparison been transposed into partial pressure, rate of reaction, temperature.

The loading in tons H_2SO_4/ton day multiplied by the fractional conversion gives the reaction rate in tons H_2SO_4 produced/ton day at the relevant temperature and mean partial pressure of SO_2, O_2 and SO_3.

In other words the treatment is as for a differential converter (*3*) in which the measured reaction rate is taken as referring to the arithmetic mean of the inlet and outlet partial pressures of reactants and products. This approximation will be justified for small conversions such as have been selected from the B.I.O.S. report.

In view of the inconsistencies present in much of the B.I.O.S. report data, no close agreement between measured and calculated figures may be looked for, but it is clear that the reaction rates calculated lie within the correct region of magnitude.

The only other relevant source of information which may provide a check on the proposed equation is summarized in Rogers Manual (*8*). Here approximate temperature coefficients of reaction rate are given for the oxidation of SO_2 with vanadium catalysts.

Corresponding coefficients may be calculated from Equation (12) if one assumes that the figures given in Rogers were calculated from data in which the reverse reaction could be neglected. This is almost certainly true in view of the large coefficients reported.

Thus

$$\frac{dk_1}{dT} = k_1 \frac{A_1}{RT^2}$$

and the coefficient of reaction rate/10° C. rise in temperature becomes

$$1 + \frac{10A_1}{RT^2} \quad (13)$$

The coefficients thus calculated from the energy of activation $A_1 = 31$ *K*cal., compared with those reported in Rogers are shown in Table 3.

Some of the higher coefficients reported in Table 3 must be suspect since, for example, a coefficient of 1.8 at (450-475° C.) implies an energy of activation of about 90 *K*cal. while a coefficient of 2.2 at (400-425) gives an energy of activation of 104 *K*cal. These high energies of activation indicate that the catalyst in question has an activity far below that of commercial catalysts in current use. In fact, such energies of activation are of the same order as has been found for pure crystalline vanadium pentoxide in unpublished work by the author.

To summarize, reaction rate data from other sources are scanty and largely unsatisfactory but, where applicable, it can be said, they are in broad agreement with the reaction-rate equation suggested here.

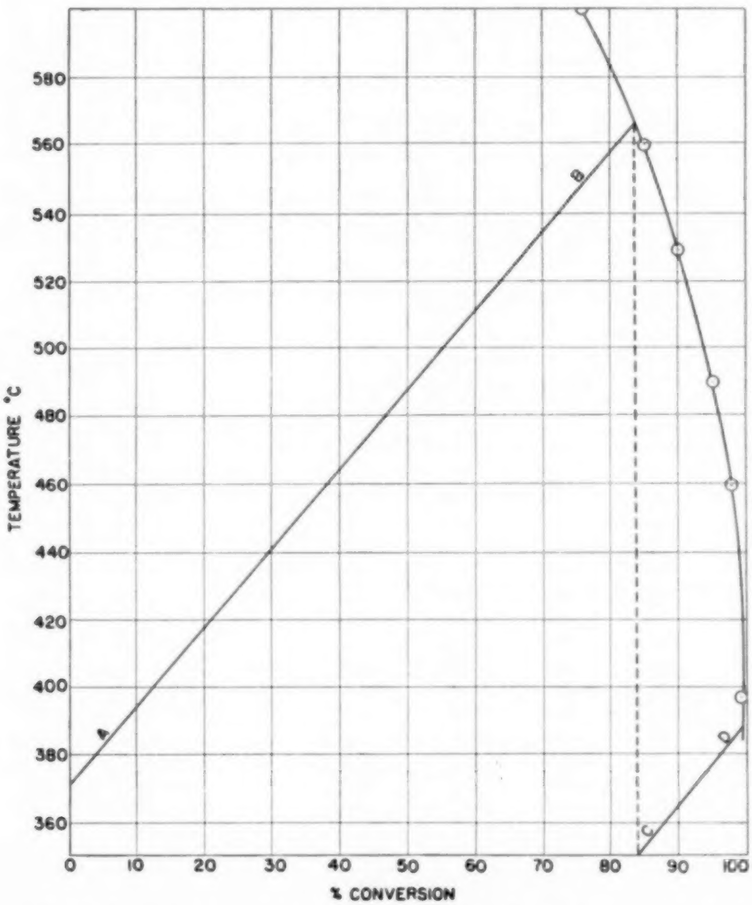

Fig. 2. Temperature-conversion equilibrium and operating lines (8% SO_2 — air feed) for 2-pass adiabatic converter.

It is therefore proposed to use this equation without further preamble for the design of contact converters of various types.

Adiabatic Converter

Adiabatic or near-adiabatic converters have been widely used in the contact process. They consist of lagged, large-diameter catalyst "bins" in which heat losses are small and the heat of reaction is taken up as sensible heat of the gases. There is thus a temperature gradient along the length of the converter and little or no temperature gradient laterally.

Figure 2 represents a plot of conversion temperature in which the curved line is the equilibrium line showing the maximum conversion obtainable at a given temperature with a feed of 8% SO_2, 92% air.

The straight line *AB* is the operating line for the first stage of an adiabatic converter with a converter-inlet temperature of 370° C. and the same feed composition. The line *AB* is drawn from the heat balance equation: $T = 2.35x + 370$ using the specific heat data of Hougen and Watson (*4*) and agrees well with that given in Rogers Manual (*8*) calculated from a U. S. Bureau of Mines paper (*9*).

It can be seen that the maximum conversion obtainable in this converter is 84%. To obtain higher conversions, the gases are then cooled to, say 350° C., and passed into a second adiabatic converter (operating line *CD* parallel to *AB*) to give a final conversion of 99%.

Greatest economy of catalyst may be realized by using more than two stages and thus reducing the temperature by smaller increments between stages.

In Table 4 the rate of reaction has been calculated from Equation (12) at a number of points along the length of the converter, using the temperature-conversion data of Figure 2.

Now if

W = weight of catalyst in tons

F = feed in equivalent tons H_2SO_4/day

r = reaction rate in tons H_2SO_4 produced/ton day

x = fractional conversion

$$r \cdot dW = F dx$$

or

$$W = F \int_0^x \frac{1}{r}\, dx \qquad (14)$$

and the weight of catalyst required to produce a conversion x may be obtained by graphically evaluating the integral between the limits x and 0 and multiplying by the feed.

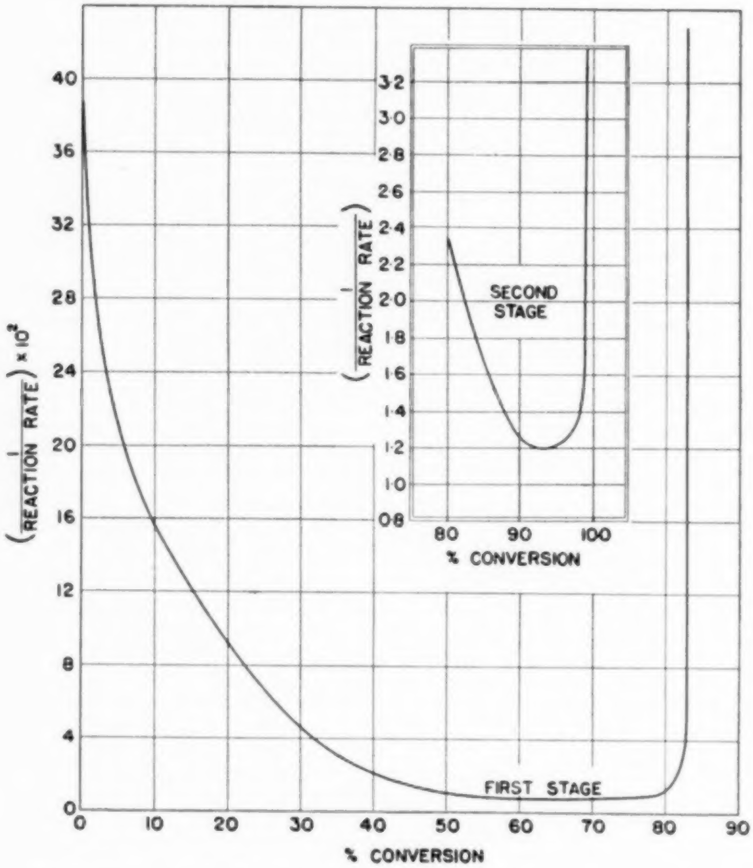

Fig. 3. Graphical evaluation of amount of catalyst required for a given conversion.

Table 4.—Adiabatic Converter (1st Stage)

Temp. °C.	Fractional Conversion	Reaction velocity constants in moles/(g.)(sec.) × 10^7 k_1	k_2	Reaction rate in tons H_2SO_4/ton day	$\left(\frac{1}{\text{reaction rate}}\right) \times 10^2$	Weight catalyst (tons) × 10^2	Weight catalyst (tons) for feed equivalent to 50 tons H_2SO_4/day
370	0	60	......	2.57	38.9	0	0
380	.04	90	0.13	3.86	25.9	F × 1.30	0.65
390	.08	140	0.23	5.67	17.6	F × 2.18	1.09
400	.125	180	0.43	7.16	14.0	F × 2.90	1.45
410	.165	240	......	9.55	10.5	F × 3.40	1.70
420	.205	330	1.26	11.92	8.4	F × 3.78	1.89
430	.25	475	...	13.94	7.2	F × 3.92	1.96
440	.295	625	3.53	21.8	4.6	F × 4.18	2.09
450	.335	895	6.30	30.0	3.3	F × 4.34	2.17
460	.38	1,200	10.9	36.4	2.75	F × 4.48	2.24
470	.42	1,600	17.4	46.8	2.14	F × 4.58	2.29
480	.46	2,090	29	......	1.7	F × 4.66	2.33
490	.50	2,700	46	70.6	1.4	F × 4.72	2.36
500	.55	3,560	72	86.28	1.2	F × 4.79	2.40
510	.59	3,600	110	87.6	1.1	F × 4.84	2.42
520	.63	5,900	173	112	0.9	F × 4.88	2.44
530	.67	7,600	250	127	0.8	F × 4.91	2.46
540	.72	10,000	400	137	0.7	F × 4.95	2.48
550	.76	12,000	590	130	0.8	F × 4.98	2.50
560	.80	15,000	860	81.6	1.23	F × 5.04	2.75
570	.85	18,800	1,260	—ve	.....	....	....

Adiabatic Converter (2nd Stage)

350	0.80	28	......	0.45	2.22	0	0
360	0.84	41	......	0.58	1.72	$F \times 7.9$	3.95
370	0.88	60	......	0.72	1.39	$F \times 14.1$	7.05
380	0.92	90	0.13	0.85	1.18	$F \times 19.2$	9.6
390	0.96	140	0.23	0.85	1.18	$F \times 23.9$	11.95
395	0.985	150	0.32	0.34	2.94	....	.....

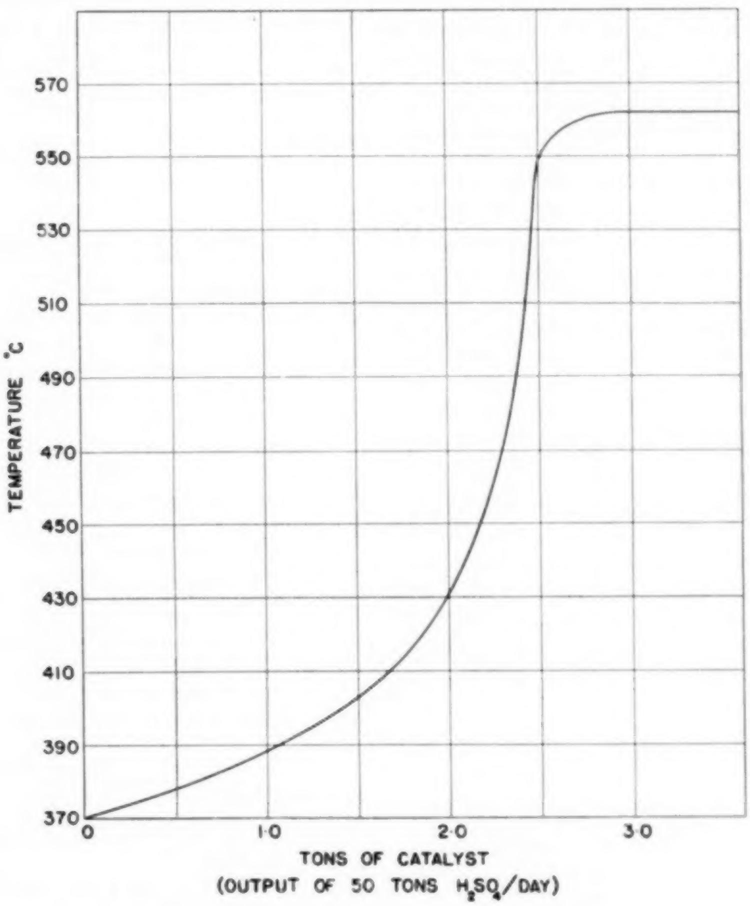

Fig. 4. Temperature distribution in adiabatic converter (1st stage).

The graphical integration procedure is shown in Figure 3; the weights of catalyst required for various conversions at a production rate of 50 tons H_2SO_4/day are shown in Table 4.

It may be seen that for a two-stage ideally adiabatic converter system, operating under the conditions described and producing 50 tons H_2SO_4/day, 14.7 tons of catalyst are required to give an over-all conversion of 96%, some four-fifths of this catalyst being in the second converter. It is worth pointing out that the foregoing analysis applies to a strictly adiabatic system where mass-transfer effects are negligible. From Table 4, the temperature distribution in the converter follows and is plotted in Figure 4.

Should any measurements on temperature distribution in adiabatic converters become available, comparison with Figure 4 would provide a valuable check on the kinetic equation used in this work.

Converters with Integral Heat-Exchangers

It is clear that the adiabatic converter involves the use of large amounts of catalyst and much smaller amounts are feasible when temperatures are regulated to achieve maximum reaction rates at all stages in the conversion.

The temperature at which the reaction rate will be a maximum is given by the criterion

$$\frac{dr}{dT} = 0 = k_1 \frac{A_1}{RT^2} \frac{P_{O_2} \cdot P_{SO_2}}{P_{SO_3}^{1/2}} - k_2 \frac{A_2}{RT^2} \frac{P_{SO_3} \cdot P_{O_2}^{1/2}}{P_{SO_2}^{1/2}} \qquad (15)$$

$$\therefore \frac{k_1}{k_2} = K_p = \frac{A_2}{A_1} \frac{P_{SO_3}}{P_{SO_2} \cdot P_{O_2}^{1/2}}$$

where K_p is the thermodynamic equilibrium constant or

$$K_p = 1.73 \frac{P_{SO_3}}{P_{SO_2} \cdot P_{O_2}^{1/2}} \qquad (16)$$

Table 5.—Converter with Optimum Temperature Distribution

Temp. °C.	Fractional Conversion	Reacion velocity constants in moles/(g.)(sec.) × 10^7 k_1	k_2	Reaction rate in tons H_2SO_4/ton day	$\left(\frac{1}{\text{Reaction rate}}\right) \times 10^2$	Wt. of catalyst (tons) × 10^2	Wt. of catalyst (tons) for feed equivalent to 50 tons H_2SO_4/day
560	0	15,000	860	.....	......	0	0
560	0.80	15,000	860	81.6	1.23	$F \times 0.98$	0.49
540	0.85	10,000	400	55.3	1.99	$F \times 1.06$	0.53
520	0.89	5,900	173	25.9	3.86	$F \times 1.18$	0.59
500	0.92	3,560	72	13.3	7.52	$F \times 1.35$	0.675
480	0.94	2,090	29	7.48	13.4	$F \times 1.56$	0.78
460	0.955	1,200	10.9	3.57	28.0	$F \times 1.87$	0.93
440	0.97	625	3.53	1.87	53.5	$F \times 2.48$	1.24
420	0.98	330	1.26	0.79	127	$F \times 3.38$	1.69
400	0.99	180	0.43	0.22	454	$F \times 6.28$	3.14

A conversion vs. optimum-temperature curve may thus be constructed from the above equation by substituting the values of the partial pressures of SO_3, O_2 and SO_2 for a given conversion, evaluating K_p and finding the temperature corresponding to this value of the equilibrium constant.

This temperature represents the temperature for a maximum rate of reaction at the conversion used in its evaluation.

Another criterion is, however, involved, which is that too high temperatures result in a shortening of the effective life of the catalyst. A temperature of 560° C. has been chosen as being approximately the maximum generally considered desirable in commercial practice. Any higher temperature would appreciably shorten the life of the catalyst without any considerable saving in its amount.

Table 5 shows optimum temperatures for various conversions which have been calculated as described, with the proviso that no temperature may exceed 560° C.

By the same graphical-integration procedure as already outlined, the weights of catalyst required for various conversions with the new optimum-temperature distribution have been calculated and are shown in Table 5.

It may be seen that the weight of catalyst required for 96% conversion of a feed equivalent to 50 tons H_2SO_4/day (composition 8% SO_2) is 0.93 tons, i.e., about 1/15th of the weight required with a two-stage adiabatic system.

In Figure 5, the optimum-temperature distribution along the length of the catalyst bed is plotted from Table 5. The temperature distribution in a commercial converter fitted with heat-exchangers [The Jaeger Converter (*8*)] is also shown.

It may be seen that there is little difference between the calculated optimum-temperature distribution and that obtaining in this converter fitted with automatic heat-exchanger and air-cooler.

It is of interest to note that a well-known company currently manufactures a two-stage converter system which employs 4.4 tons of vanadium catalyst to give an output of 50 tons of H_2SO_4/day. If this performance is compared with the 14.7 tons of catalyst required by an adiabatic reactor and the 0.93 tons required by a reactor having an ideal temperature distribution, it may be concluded that current design practice has moved in large measure towards the optimum conditions outlined here.

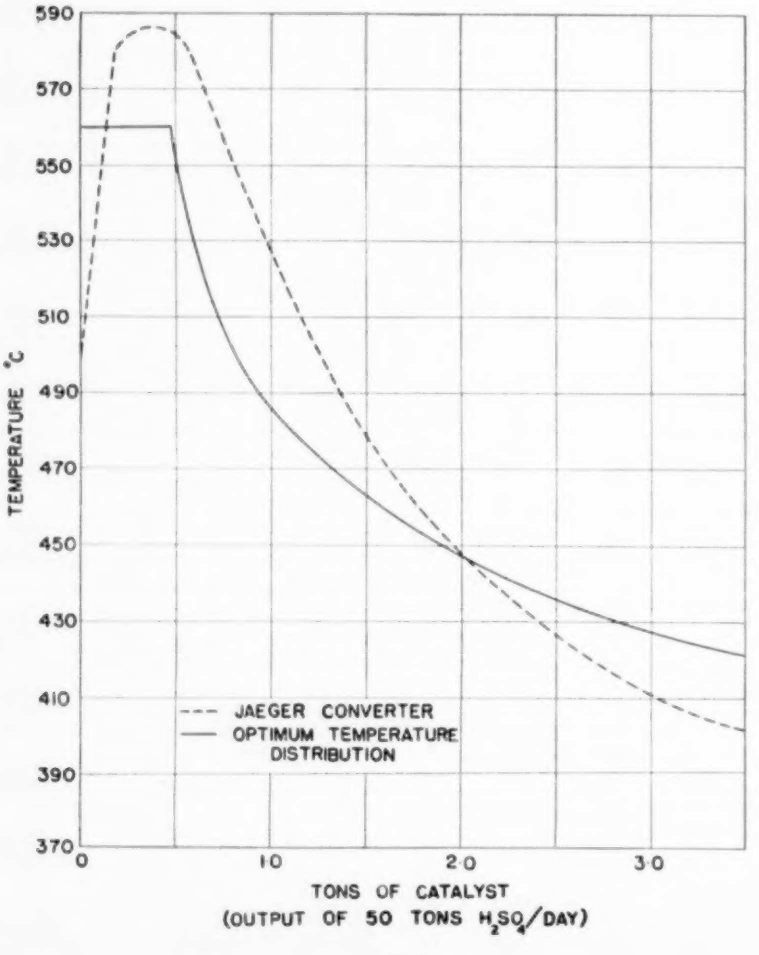

Fig. 5. Temperature-distributions in converters.

Notation

r = reaction rate in various units

$P_{SO_2}, P_{O_2}, P_{SO_3}$ = partial pressures of SO_2, O_2 and SO_3 in atmospheres

Kcal = kilocalories

k_1 = reaction velocity constant of forward reaction

k_2 = reaction velocity constant of reverse reaction

ΔH = heat of reaction

A_1 = energy of activation of forward reaction

A_2 = energy of activation of reverse reaction

T = absolute temperature in ° K.

R = gas constant

x = fractional conversion

K_p = equilibrium constant in terms of partial pressures

W = weight of catalyst, tons

F = feed rate, equivalent tons H_2SO_4/day

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Liquid-Liquid Spray-Tower Operation in Heat Transfer

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Heat transfer in a liquid-liquid spray tower, 2 in. I.D. and 6 ft. long, was studied. The system used was benzene-water, with the benzene phase dispersed. The dispersed phase rate was varied from 45-185 cu. ft./(hr.)(sq. ft.), and the water phase rate covered the range 65-275 cu. ft./(hr.)(sq. ft.). Observations were made of the number of nozzles in the dispersed phase distributor which operated under various conditions. It was noted that new nozzles come into operation when the linear velocity of the dispersed phase fluid through the nozzles already in operation exceeded about 10 cm./sec. Drop sizes were measured. These were independent of the continuous phase rate and predictable by the correlation of Hayworth and Treybal *(8)*. Measurements of the velocity of rise of the dispersed phase droplets permitted holdup calculations.

Area heat-transfer coefficients were found to be a function of holdup only, for a particular direction of heat transfer. They ranged from 30-70 B.t.u./(hr.)(sq. ft.)(°F.). They remained constant at first, and then decreased as the holdup was further increased. This may be explained by partial obstruction of the interfacial area by closely packed droplets. Hindered rising of the droplets may also be a factor.

There seems to be a moderate end effect at the dispersed phase entry point when heat transfer takes place from the continuous to the discontinuous phase, but not when the reverse occurs.

Changes in the ratio of the heat-transfer coefficient obtained by graphical integration to that based on the logarithmic mean driving force may provide some evidence for recirculation at the higher holdups.

THE analysis of the performance characteristics of spray towers has been marked by much uncertainty. This has been due mainly to the lack of knowledge of the interfacial surface existing in the tower, through which surface the diffusional processes must take place. It is the purpose of this paper to present the results of a study of a liquid-liquid spray tower, using the system benzene-water. Heat transfer was used instead of mass transfer. This operation was selected because of its simplicity and convenience, as well as its potential application to direct heat transfer between immiscible liquid systems. It is recognized that such a heat-transfer approach presents problems in the analysis and interpretation of data, for temperature has a pronounced effect on the properties of liquid-liquid systems.

Recent studies of liquid-liquid systems include the work of Hayworth and Treybal (*8*) on a single nozzle injecting one liquid into a stagnant phase of the second liquid. Drop sizes were correlated as a function of the velocity through the nozzle, the nozzle diameter, and the physical properties of the system. Elgin and Browning (*3*), Sherwood, Evans and Longcor (*15*), Johnson and Bliss (*9*), Appel and Elgin (*1*), Blanding and Elgin (*2*), Nandi and Viswanathan (*12, 13*), Licht and Conway (*10*), West et al. (*17*), Peterson (*14*), and Hardy (*7*) have studied various aspects of the problem. In some of these investigations, the work relating to drop size, holdup, and related phenomena was carried out with mass transfer occurring between the two phases. End effects at the continuous-phase entrance of spray towers have been reported by Geankoplis and his co-workers (*5, 6*). A limiting flow and holdup study in a spray tower has recently been made by Minard and Johnson (*11*). Some work on heat-transfer coefficients in a spray tower has been cited by Treybal (*16*).

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Equipment

A flow diagram of the experimental setup is shown in Figure 1. This applies for the case of water entering the column hot and being cooled by the benzene. When the heat transfer was in the reverse direction, a deaerator was used to eliminate air from the dispersed-benzene phase prior to its being heated. This addition to the equipment is shown in Figure 2.

Laboratory tap water and technical grade benzene were employed.

The column was constructed of eight 2-in. Pyrex glass pipe tees, as shown in Figure 3. The tees were so connected that the branches of the tees were successively rotated 120° from one another. The effective length of the column was 73 in.

A detail of the distributor assembly is given in Figure 4. The top ends of the nozzles were beveled to an angle of approximately 45°. The

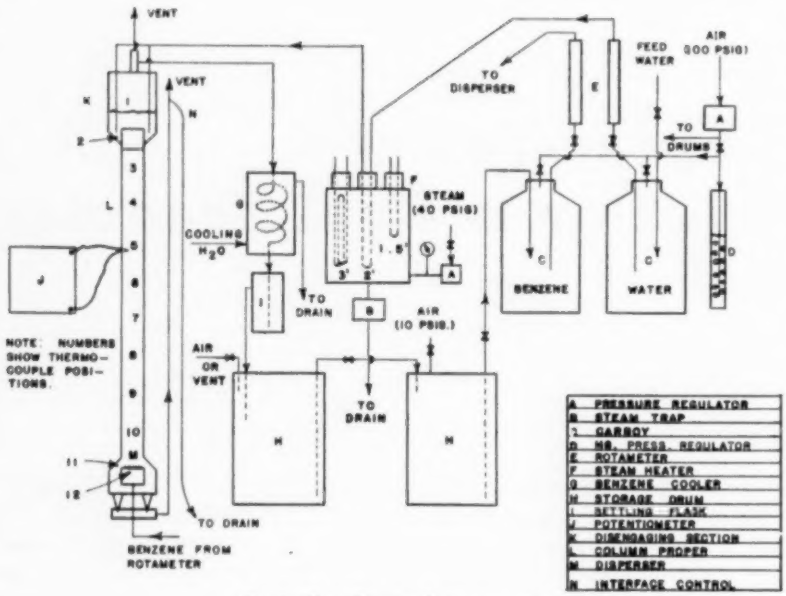


Fig. 1. Flow diagram—hot water runs.

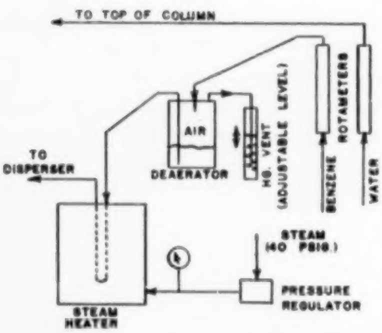


Fig. 2. Flow diagram—modification for hot benzene runs.

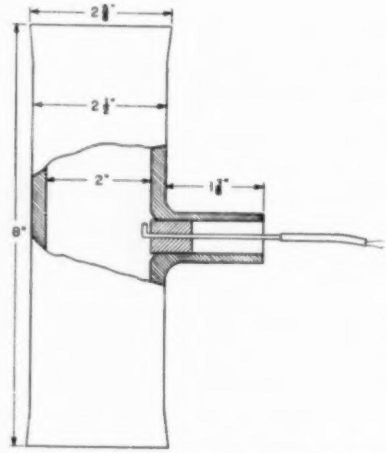


Fig. 3. Section of column Pyrex tee, showing thermocouple installation.

distributor was positioned in the bottom enlarged section with the nozzle tips about 1½ in. below the beginning of the 2-in. diam. column proper.

The liquid-liquid interface was maintained about 1 in. above the top of the continuous-phase weir.

The heater consisted of a steam chest containing separate sections of ⅜-in. copper tubing of different lengths. Provisions were made to use these sections singly or in any desired combination.

Two 12-gal. Pyrex carboys were used for the feed reservoirs. They operated under a pressure of about 7 lb./sq.in. gauge. The benzene make-up was taken from a 35-gal. drum under a pressure of 10 lb./sq.in.

The flow of each liquid was controlled by means of a pinch clamp acting on a short section of Tygon tubing in the feed line upstream of its rotameter. The rotameters were used only to indicate constancy of flow. The actual flow was obtained by timing the exit streams.

All lines were ⅜-in. copper tubing except the vented adjustable leg which controlled the location of the interface. Tygon tubing was used here to secure greater flexibility.

Chromel-constantan thermocouples were constructed and used for temperature measurements within the column. One couple was installed in the branch of each of the eight tees in the column (see Fig. 3); two were installed at each end of the column to provide inlet and outlet stream temperatures. Small diameter glass tubing and neoprene stoppers were used to hold the tee thermocouples in place. The glass tubing was turned upward about ¼ in. inside the column. The thermocouple junction projected slightly out of the glass tubing and came in contact with the continuous-phase flowing down the column. Leakage out of the column through the glass tube was prevented by a clamp. This compressed a small section of rubber tubing through which the thermocouple leads passed as they left the column.

The leads of the four thermocouples at the ends of the column were brought out through small holes in the end-plate gaskets.

The purpose behind the 120° rotation of the thermocouples was to minimize turbulence produced by the presence of the couples and help obtain an accurate temperature profile of the continuous phase of the column. Visual observations indicated that the presence of the thermocouples had a negligible disturbing effect on column operation.

The thermocouple potentials were measured with a potentiometer sensitive to 0.005 mv. This corresponds to a temperature uncertainty of slightly more than 0.1° F. The couples were calibrated in place in the column.

Because the lens effect of a cylindrical body of water distorts the image of an object within it, it was necessary, in the measurement of drop sizes, to determine distortion factors in various directions at various depths in order to be able to translate image dimensions to object dimensions. Photographs were taken with a 35-mm. camera of glass marbles of known size, placed at various locations in the column cross section, the column being filled with water. A standard camera-to-column distance was adopted. The prints were enlarged to natural size in all dimensions by printing on a curved surface having the same radius of curvature as the column itself.

The distortion factors thus obtained were applied to images of benzene droplets rising within the column during actual operation. The technique of taking the photographs and making the print enlargements was identical with that used for the calibration work.

Figure 5 is a photograph of the type of distortion produced by the water in the column. The glass spheres shown are identical in size.

Figure 6 is a photograph of the column as it appeared while operating under conditions of high holdup.

Procedure

The particulars in the following description apply to the case of water entering the column hot.

Water was introduced into the column at the desired rate. Steam was turned on to the heater. About 30 min. were allowed for the heater and column to reach steady temperatures. Benzene flow was then started. The benzene leaving the column was cooled to approximately 80° F. before being sent to the settling flask (Item I in Fig. 1) to remove any water accidentally entrained by it. The time required to reach steady-state operating conditions after the start

of benzene flow varied from 10 to 25 min., for high- and low-water rates respectively.

The velocity of rise could be measured over a distance of only 6 in. A drop was timed from the moment of its appearance over the lower flange of the section to its disappearance behind the upper flange. Twenty drops were timed. The mean velocity of rise was calculated.

The average drop size was obtained from each photograph by measuring twenty-four droplet images to the nearest 0.01 in. Distortion factors were applied to each drop image to get the true major and minor diameters of the drop.

Variations in temperature from point to point in the column produced minor variations in the velocity of rise and in drop dimensions. Observations were made in the section containing thermocouple No. 8 because conditions in this section were close to average.

The number of distributor nozzles operating was much affected by the degree to which water had penetrated into the nozzles and had wetted them. Good reproducibility of operation was secured by temporarily increasing the benzene rate to a high value to force all water out of the distributor and causing all the nozzles to operate, and then cutting back to the desired flow rate.

The e.m.f. of each of the twelve thermocouples was recorded. Room temperature was measured with a thermometer located at the middle of the column and about 4 in. away from it.

There was some difficulty encountered with the release of dissolved air from the dispersed phase (benzene) upon being heated. This was minimized when the benzene inlet stream was the hot stream by deaerating the benzene prior to its entry into the heater (see Fig. 2). When the benzene entered the column cold, the deaerator was not used, but the water temperature was held low enough to prevent excessive heating of the benzene stream as it rose through the column. If the benzene droplet was allowed to undergo an excessive increase in temperature, it tended to produce a small gas bubble at its top surface; this bubble, when permitted to become large, materially affected the liquid drop shape and its velocity of rise.

The range of flow rates investigated covered, insofar as possible, the complete limits of capacity of the column. It was regarded that the column was in a condition of incipient flooding when the benzene droplets began to accumulate in the lower enlarging section of the tower, but not to the point where they interfered with drop formation at the disperser nozzle.

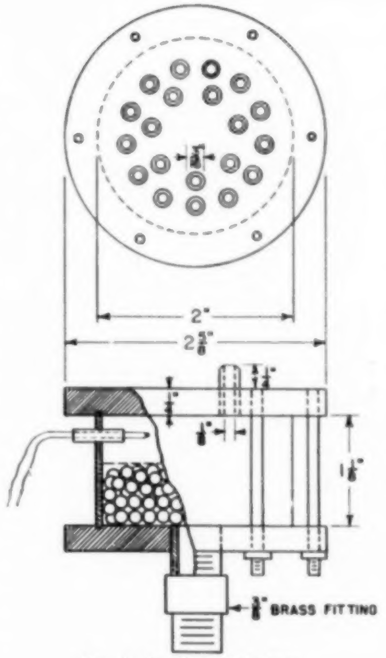


Fig. 4. Detail of distributor.

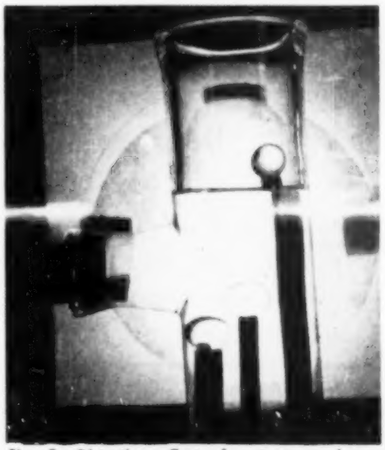


Fig. 5. Distortion effect of water on spheres.

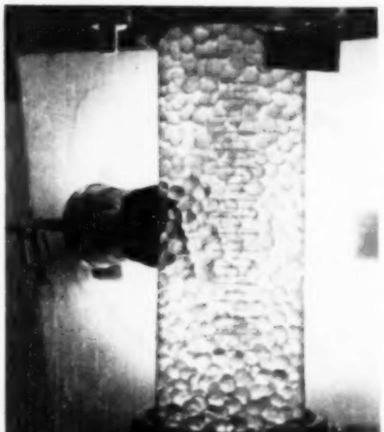


Fig. 6. Appearance of column under conditions of high holdup.

Calculations

The major and minor diameters of the drop were obtained experimentally from the photographs. The equivalent diameter (the diameter of a sphere possessing the same volume as the drop) was calculated from the major and minor diameters, assuming an oblate spheroidal shape for the drop. The equivalent diameter is of value in comparing the results of the present investigation with those of Hayworth and Treybal (*8*).

The interfacial area was also calculated from the major and minor diameters of the drop.

The absolute holdup, expressed as cubic feet of dispersed benzene present in the column, was calculated by:

$$H_{abs} = \frac{L_e B}{3600v} \qquad (1)$$

The fractional holdup is the absolute holdup divided by the effective column volume:

$$H_{fr} = \frac{B}{3600vS} \qquad (2)$$

The velocity of the benzene through the operating nozzles in the distributor (also called the tip velocity) is given by:

$$v_t = \frac{B}{(3600)(0.785d_t^2)(n_t)} \qquad (3)$$

$$v_t' = 30.48v_t \qquad (4)$$

The heat transferred between the continuous and discontinuous phases was calculated from the enthalpy change of the discontinuous phase, since some heat transfer was also taking place between the water and the surrounding air.

Two heat-transfer coefficients were calculated, a logarithmic-mean value and a more rigorous one.

The logarithmic-mean coefficient was calculated in the usual way from the temperature driving force existing at each end of the column, even though the column was known not to be operating under strictly adiabatic conditions. The coefficient was assumed to be constant over the entire column length.

The more rigorous coefficient was derived as follows:

Considering the case of water as the hot phase,

$$dQ_w = M_w C_w dt_w \qquad (5)$$

$$dQ_b = M_b C_b dt_b \qquad (6)$$

It is possible to calculate a heat-loss coefficient from the water to the surrounding air. It was based on the outside area of the column. This coefficient, U_L, is defined as follows:

$$dQ_L = U_L(t_w - t_a)dA_L$$

$$= U_L a_L'(t_w - t_a)dZ \qquad (7)$$

Over a differential length,

$$-dQ_w = dQ_L - dQ_b. \qquad (8)$$

Substituting, and integrating from the top of the column to any point in the column,

Table 1.—Column Operation Data—Hot Water Runs

			t_w		t_b									
Run	W	B	Couple 2	Couple 11	Couple 1	Couple 12	n_t	v_t'	D_j	D_n	$V_d \times 10^5$	$A_d \times 10^2$	v	H_{fr}
1	1.463	0.995	144.1	127.0	135.2	90.7	13	7.6	0.332	0.282	0.923	2.155	0.318	0.040
2	1.463	1.493	144.1	124.4	138.2	89.4	16	9.3	0.334	0.288	0.956	2.185	0.292	0.065
3	1.463	2.00	143.7	118.5	137.6	90.9	16	12.4	0.320	0.275	0.840	2.01	0.261	0.098
4	1.463	2.44	142.2	107.6	134.1	82.7	20	12.1	0.323	0.285	0.869	2.06	0.257	0.121
5	1.463	2.96	142.4	103.3	134.6	84.0	20*	14.7	0.274	0.253	0.553	1.51	0.218	0.173
6	1.463	3.40	141.7	98.1	133.7	85.5	20*	16.8	0.264	0.240	0.493	1.40	0.186	0.233
7	1.463	3.86	138.9	86.9	129.2	80.0	20*	19.2	0.263	0.250	0.512	1.43	0.147	0.334
8	1.92	0.995	146.1	132.9	138.9	82.2	12	8.2	0.347	0.292	1.076	2.38	0.313	0.041
9	1.94	1.44	146.4	127.9	139.1	82.5	16	8.9	0.349	0.272	1.004	2.28	0.289	0.064
10	1.92	1.87	147.7	124.5	140.5	83.8	19	9.8	0.346	0.274	1.004	2.28	0.273	0.087
11	1.94	2.44	144.1	114.0	138.0	78.6	20	12.1	0.332	0.278	0.923	2.155	0.253	0.123
12	1.98	2.96	144.1	111.9	138.7	83.9	20*	14.6	0.285	0.259	0.617	1.625	0.208	0.181
13	1.94	3.33	144.7	105.6	140.0	82.5	20*	16.6	0.266	0.247	0.553	1.51	0.185	0.230
14	1.98	3.51	144.8	102.6	139.0	83.1	20*	17.8	0.267	0.240	0.530	1.47	0.127	0.362
15	2.97	1.06	141.6	132.3	135.7	82.9	12	8.8	0.357	0.265	0.990	2.32	0.292	0.046
16	2.97	1.45	141.3	129.3	136.5	83.4	15	9.6	0.337	0.267	0.947	2.18	0.281	0.046
17	2.97	1.97	142.3	126.8	137.5	81.0	17	11.5	0.327	0.275	0.892	2.10	0.257	0.098
18	2.97	2.40	144.0	125.3	140.5	82.4	19	12.2	0.329	0.277	0.923	2.155	0.242	0.126
19	2.97	2.90	143.5	121.5	140.8	83.4	20*	14.4	0.293	0.245	0.612	1.62	0.175	0.211
20	2.97	3.32	143.1	116.5	140.0	82.9	20*	16.4	0.265	0.236	0.493	1.40	0.145	0.292
21f	2.945	3.60	139.2	112.2	135.7	81.6	20*	17.4	0.263	0.244	0.492	1.40	0.149	0.300
22	3.805	1.024	140.2	134.6	134.7	84.1	11	9.2	0.353	0.270	1.004	2.28	0.305	0.043
23	3.805	1.505	140.3	132.1	135.9	85.0	15	10.0	0.348	0.276	1.040	2.33	0.295	0.065
24	3.805	1.99	139.4	128.3	134.4	80.0	19	10.4	0.338	0.276	0.985	2.24	0.281	0.090
25	3.86	2.44	140.8	126.3	138.6	77.8	20	12.1	0.321	0.269	0.840	2.01	0.218	0.143
26	3.805	2.96	138.1	121.5	134.8	81.2	20*	14.7	0.306	0.262	0.759	1.87	0.193	0.195
27f	3.86	3.25	142.0	122.0	139.8	79.2	20*	16.1	0.270	0.243	0.530	1.47	0.137	0.302
28	4.90	1.028	136.6	132.1	132.5	76.4	11	9.3	0.350	0.267	1.004	2.28	0.284	0.044
29	4.90	1.45	142.0	134.9	138.2	77.1	15	9.6	0.337	0.273	0.947	2.18	0.258	0.072
30	4.90	1.88	140.9	131.4	138.0	77.4	19	9.8	0.338	0.267	0.947	2.18	0.246	0.098
31	4.875	2.43	138.4	127.3	135.0	79.8	20	12.0	0.329	0.269	0.892	2.10	0.183	0.162
32	4.90	2.86	141.6	127.3	139.8	77.8	20*	14.2	0.312	0.264	0.759	1.87	0.143	0.256
33f	4.90	3.03	140.5	126.0	139.5	79.5	20*	15.0	0.282	0.254	0.593	1.59	0.123	0.314
34	5.87	1.038	143.4	139.5	140.9	83.8	12	8.6	0.340	0.254	0.875	2.45	0.284	0.044
35	5.87	1.505	142.6	136.9	140.5	84.9	17	8.8	0.331	0.267	0.892	2.10	0.243	0.079
36	5.87	1.98	144.3	136.3	142.6	84.1	20	9.8	0.312	0.261	0.759	1.87	0.208	0.122
37	5.87	2.43	141.7	132.7	140.5	84.0	19	12.7	0.312	0.257	0.759	1.87	0.155	0.199
38f	5.87	2.73	141.2	131.0	140.4	83.2	20*	13.5	0.291	0.254	0.640	1.67	0.136	0.256

* Jet production by distributor nozzles. Dispersed-phase droplets formed by breaking away from ends of jets.
f—Operation under conditions of flooding.

$$-Q_w = \int_O^Z U_L a_L' (t_w - t_a) dZ + \int_{t_b}^{t_{b_1}} M_b C_b dt_b, \qquad (9)$$

and

$$M_w C_w (t_{w_2} - t_w) = U_L a_L' \int_O^Z (t_w - t_a) dZ + M_b C_{b\ avg.} (t_{b_1} - t_b) \qquad (10)$$

Since e.m.f. readings were taken all along the column length, t_w is known experimentally as a function of Z. Hence, the integral in Equation (10) can be evaluated graphically, the limits being the top of the column and any point in the column, Z. As will be shown later, $U_L a_L'$ can be evaluated from the column heat-loss data. From the value of the integral and $U_L a_L'$, t_b at point Z in the column can be calculated by means of Equation (10); when this is done for several values of Z, t_b is obtained as a function of length.

The area heat-transfer coefficient between the water and benzene, U, is defined:

$$-dQ_b = Ua' (t_w - t_b) dZ. \qquad (11)$$

Thus,

$$M_b C_{b\ avg.} (t_{b_1} - t_{b_{12}}) = Ua' \int_O^{L_e} (t_w - t_b) dZ, \qquad (12)$$

where U is taken as a constant and Ua' is taken outside the integral. The integral can be evaluated graphically and an average rigorous U thus obtained for the column.

As pointed out above, the heat-loss coefficient $U_L a_L'$ had to be obtained in order to carry out the calculations for U. To achieve this, the results of the hot water runs were employed. Heat losses were usually negligible in the hot benzene runs. By the definition of U_L,

$$U_L a_L' = \frac{Q_L}{\int_O^Z (t_w - t_a) dZ} \qquad (7a)$$

Q_L is a small value, obtained by difference between Q_w and Q_b, both large quantities. Hence, great care had to be exercised in selecting accurate values of Q_L for the calculation of $U_L a_L'$. The hot water runs were divided into groups having approximately the same temperature difference between the water in the column and the outside air. An average Q_L was calculated

Table 2.—Column Operation Data—Hot Benzene Runs

Run	W	B	t_w Couple 2	t_w Couple 11	t_b Couple 1	t_b Couple 12	n_t	v_t'	D_j	D_n	V_d $\times 10^3$	A_d $\times 10^3$	ψ	H_{tr}
39	1.482	1.450	77.9	99.5	81.2	138.5	14	10.3	0.296	0.275	0.736	1.837	0.297	0.062
40	1.980	1.450	77.3	93.4	80.0	133.2	14	10.3	0.315	0.256	0.759	1.870	0.280	0.066
41	3.00	1.450	76.4	87.7	77.7	141.1	15	9.6	0.279	0.252	0.593	1.591	0.256	0.072
42	3.91	1.450	80.0	87.9	81.2	138.2	14	10.3	0.304	0.259	0.710	1.782	0.242	0.076
43	4.85	1.450	77.4	84.3	78.1	139.4	13	11.1	0.300	0.265	0.710	1.782	0.221	0.084
44	5.95	1.450	74.3	81.3	74.9	142.2	14	10.3	0.301	0.268	0.736	1.837	0.213	0.087
45	1.444	1.95	77.0	111.3	81.7	150.9	19	10.2	0.305	0.264	0.710	1.782	0.308	0.081
46	1.99	1.94	75.3	99.5	78.3	143.6	19	10.2	0.288	0.262	0.663	1.712	0.274	0.091
47	2.98	1.96	74.6	89.8	75.9	137.6	18	10.8	0.295	0.266	0.683	1.750	0.251	0.099
48	3.86	1.96	74.1	86.2	75.2	143.6	19	10.2	0.300	0.264	0.710	1.782	0.232	0.107
49	4.90	1.96	74.5	84.0	75.1	139.7	19	10.2	0.297	0.267	0.736	1.837	0.199	0.125
50	5.99	1.96	77.4	86.5	77.5	148.6	18	10.8	0.295	0.252	0.640	1.670	0.182	0.137
51	1.478	2.45	78.7	118.1	84.1	152.0	19	12.8	0.288	0.263	0.663	1.712	0.251	0.124
52	1.981	2.45	77.4	110.5	80.1	153.9	19	12.8	0.288	0.256	0.663	1.712	0.235	0.133
53	3.02	2.45	75.9	98.1	77.2	149.5	19	12.8	0.289	0.254	0.640	1.670	0.224	0.140
54	3.89	2.45	74.9	93.8	75.2	156.6	19	12.8	0.286	0.251	0.640	1.670	0.187	0.167
55	4.94	2.45	73.5	89.7	73.6	160.9	19	12.8	0.276	0.252	0.593	1.591	0.146	0.214
56f	5.425	2.45	75.2	87.9	75.3	160.8	19	12.8	0.291	0.256	0.663	1.712	0.074	0.423
57	1.483	2.925	80.3	132.1	85.1	156.5	19*	15.3	0.246	0.236	0.454	1.329	0.203	0.184
58	1.97	2.96	78.0	121.1	80.3	157.9	19*	15.3	0.242	0.227	0.402	1.220	0.180	0.210
59	2.96	2.96	75.8	104.7	76.7	156.2	19*	15.3	0.251	0.243	0.454	1.329	0.139	0.272
60f	3.45	2.96	73.3	101.0	73.5	165.7	19*	15.3	0.244	0.236	0.418	1.257	0.075	0.504
61	1.483	3.415	77.1	139.6	85.5	158.4	19*	17.8	0.236	0.218	0.384	1.187	0.201	0.217
62	1.991	3.415	76.5	128.4	78.8	160.4	19*	17.8	0.249	0.231	0.436	1.289	0.169	0.258
63f	2.545	3.415	74.2	116.9	74.6	161.4	20*	17.9	0.248	0.246	0.473	1.363	0.079	0.581
64	1.483	4.00	77.6	147.2	88.8	160.4	20*	19.8	0.230	0.231	0.369	1.155	0.167	0.306
65f	1.940	4.00	75.6	140.6	78.3	161.4	20*	19.8	0.239	0.244	0.419	1.257	0.069	0.739

* Jet production by distributor nozzles. Dispersed phase droplets formed by breaking away from ends of jets.

f—Operation under conditions of flooding.

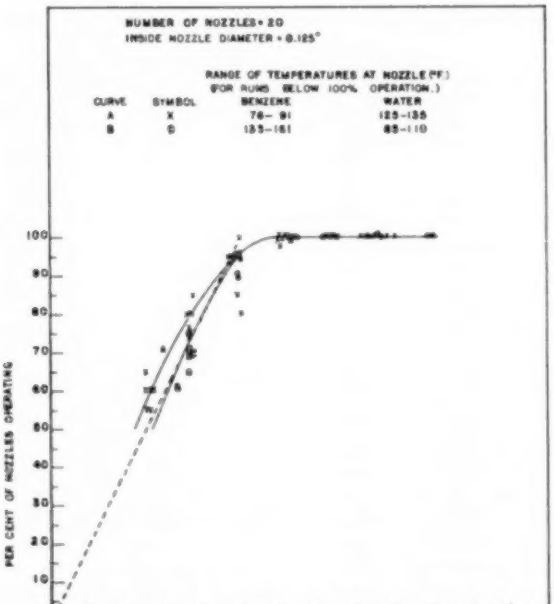


Fig. 7. Characteristics of distributor operation.

for each such group. An actual run in each group whose Q_L compared well with the average of the group was selected for a calculation of $U_L a_L'$ by graphical means, as indicated by Equation (7a). The actual Q_L of the particular run was used, not the average Q_L of the group. Nine such typical runs were selected and used for the $U_L a_L'$ calculations. Values obtained agreed well, the mean being 0.65 B.t.u./(hr.)(ft.)(°F.). This mean value was used in all the calculations of U. It did not have to be known too accurately for it contributed only a small correction term. In fact, an average $U_L a_L'$ for thirty-one runs, calculated on the basis of a logarithmic-mean driving force instead of by the rigorous graphical procedure just outlined, differed from the 0.65 value by being 15% higher. It could have been used instead without any serious error in the final result.

The familiar volumetric heat-transfer coefficient, Ua, was calculated by multiplying the area coefficient U by the interfacial area per unit volume, a.

To determine whether an end effect existed at the dispersed-phase distributor, U_{lm}'s were calculated for the section of the column between thermocouples Nos. 9 and 11 as follows:

Using the heat-loss coefficient of 0.65 B.t.u./(hr.)(ft.)(°F.) and a logarithmic-mean temperature difference, the amount of heat lost in the bottom section to the air (or vice versa, if the water phase was cooler than the surrounding air) was calculated. The enthalpy change of the benzene in this section was then determined from the enthalpy change of the water and the heat loss to the air. From this, the temperature of the benzene at point No. 9 was calculated. A logarithmic-mean U for heat transfer between the liquid phases was then calculated, using the logarithmic mean Δt for this section of the column.

Although the heat-loss coefficient used here was the one obtained by graphical integration, its employment with a logarithmic-mean Δt for calculating the heat loss in the bottom portion of the column does not introduce any noticeable error because of the small amount of heat loss relative to the amount of heat transferred between phases (1 to 10% in the hot water runs, 0 to 3% in the hot benzene runs). The logarithmic-mean U was calculated here in preference to the rigorous U because of its simplicity and because it could be compared directly with the logarithmic-mean U for the entire column to ascertain if an end effect existed.

Table3.—Heat-Transfer Data—Hot Water Runs

Run	Q_h	A, Interfacial	U_{lm}	Ua	U_{rig}	U_{rig}/U_{lm}	U_{lm} (distributor sect.)
1	1040	1.24	42.0	390	....	....	....
2	1705	1.97	53.0	785	52.5	0.99	40.0
3	2180	3.10	49.6	1210	49.2	0.99	48.2
4	2935	3.83	51.2	1540	50.4	0.98	50.3
5	3500	6.27	44.3	2180	....	....	37.0
6	3830	8.78	42.8	2960	45.5	1.06	45.5
7	4450	12.43	43.2	4220	40.7	0.94	....
8	1320	1.19	50.0	468	46.5	0.93	40.8
9	1890	1.91	47.5	712	46.2	0.97	50.8
10	2480	2.63	48.8	1010	....	....	53.0
11	3350	3.70	52.0	1510	56.0	1.08	60.4
12	3790	6.32	43.8	2160	....	....	57.2
13	4480	8.30	47.0	3060	48.9	1.04	54.0
14	4580	11.30	36.0	3200	35.8	1.00	52.7
15	1310	1.44	44.8	507	....	....	71.2
16	1800	2.01	49.6	782	....	....	87.0
17	2600	3.05	47.3	1135	....	....	59.1
18	3260	3.90	53.6	1640	57.9	1.08	65.0
19	3880	7.40	39.5	2300	....	....	48.0
20	4430	11.00	32.4	2800	38.0	1.17	52.3
21f	4560	13.33	27.6	2890	34.1	1.24	47.7
22	1215	1.29	46.7	473	....	....	59.5
23	1790	1.93	51.3	780	55.2	1.08	67.0
24	2580	2.72	49.4	1057	53.0	1.07	61.3
25	3460	4.52	51.3	1820	59.5	1.16	63.3
26	3710	6.37	39.6	1980	....	....	....
27f	4590	11.13	35.3	3090	43.3	1.23	48.5
28	1350	1.32	51.8	546	....	....	69.2
29	2035	2.18	47.3	777	....	....	67.3
30	2670	2.98	51.5	1155	57.0	1.10	71.8
31	3140	4.60	41.2	1425	....	....	67.3
32	4125	8.33	34.6	2170	41.5	1.20	54.2
33f	4240	11.28	31.9	2710	38.5	1.21	52.3
34	1355	1.63	48.8	598	....	...	55.3
35	1950	2.46	51.2	947	45.5	0.89	51.8
36	2685	3.96	44.6	1330	54.1	1.21	69.2
37	3200	6.52	38.3	1880	....	....	52.2
38f	3640	8.85	30.6	2040	42.5	1.39	52.8

Comment on Results

Essential data are presented in Tables 1-4.

DISTRIBUTOR OPERATION

It was noted that at benzene flow rates sufficiently low so that not all the nozzles operated, a "pulsing" type of drop formation (individual drop production) prevailed. When the flow rate was increased a little past the point where all the nozzles operated, jets were produced instead, the droplets being formed by breaking away from the ends of the jets. The jets appeared simultaneously in all the nozzles. The nozzle velocity at which this marked change in drop formation mechanism occurred was about 13 cm./sec. This point was also characterized by an abrupt decrease in drop size. This, in turn, affected the velocity of rise.

The performance of the distributor is shown graphically in Figure 7. The benzene leaving the distributor nozzle and the continuous water phase in the vicinity of the nozzle were not in thermal equilibrium. Hence, temperature

Table 4.—Heat-Transfer Data—Hot Benzene Runs

Run	Q_h	A, Interfacial	U_{lm}	Ua	U_{rig}	U_{rig}/U_{lm}	U_{lm} (distributor sect.)
39	1980	2.05	66.9	1035	61.2	0.92	63.5
40	1800	2.16	66.5	1080	64.2	0.96	79.4
41	2100	2.57	57.9	1120	57.5	0.99	55.9
42	1930	2.54	57.6	1100	....	....	....
43	2080	2.78	60.3	1260	61.0	1.01	63.5
44	2285	2.87	60.8	1310	....	....	94.8
45	3160	2.69	72.0	1460	....	....	54.5
46	2960	3.11	62.6	1465	....	....	....
47	2820	3.36	66.5	1680	....	....	....
48	3120	3.57	61.5	1580	....	....	57.5
49	2950	4.13	58.5	1820	60.0	1.02	58.0
50	3260	4.72	71.9	2560	71.5	1.00	63.5
51	3890	4.25	59.1	1890	58.8	1.00	46.2
52	4225	4.59	63.1	2180	....	....	52.8
53	4145	4.83	63.1	2290	65.2	1.03	67.4
54	4670	5.77	69.2	3010	68.0	0.98	66.2
55	5020	7.63	61.5	3540	....	....	54.2
56f	4920	14.45	30.7	3340	....	....	31.3
57	4880	7.12	56.7	3040	55.0	0.97	49.6
58	5375	8.45	51.3	3260	46.8	0.91	50.0
59	5500	10.51	41.8	3310	....	....	....
60f	6400	20.05	28.5	4290	....	....	31.8
61	5850	8.88	51.0	3410	50.2	0.98	49.0
62	6550	10.12	57.2	4350	55.0	0.96	51.6
63f	6920	22.25	33.2	5550	42.7	1.29	40.4
64	6750	12.65	43.4	4130	47.5	1.09	39.2
65f	7800	29.40	30.1	6650	31.0	1.03	34.2

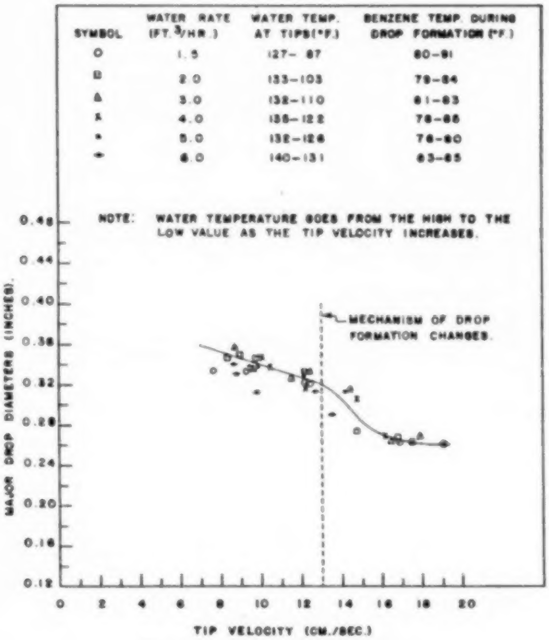


Fig. 8. Drop sizes—hot water runs.

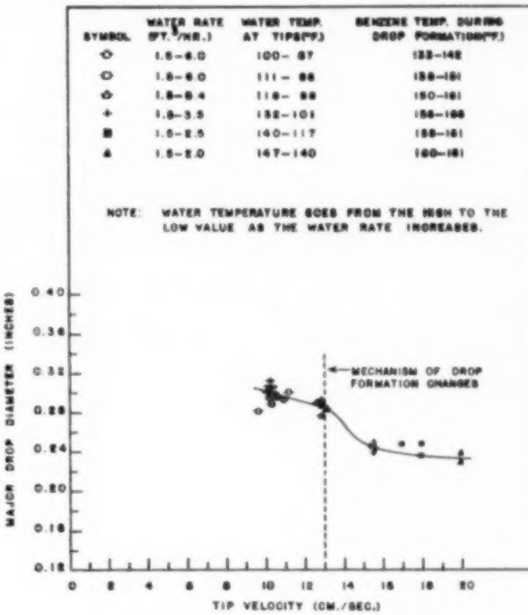


Fig. 9. Drop sizes—hot benzene runs.

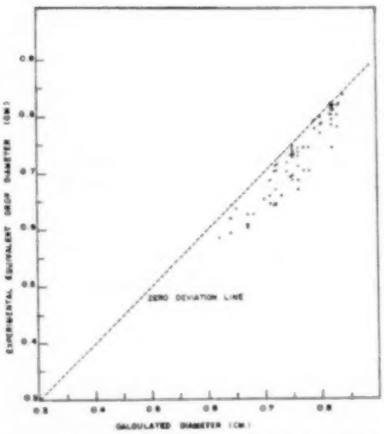


Fig. 10. Comparison of actual and calculated equivalent diameters.

ranges are designated for both phases. These temperature data are for the condition of less than 100% nozzle operation, the region of greatest interest. If the interface temperature at any point in the column is taken as the mean of the bulk benzene and water temperatures at that point, then curve A represents a condition of slightly lower average interface temperature in the vicinity of the distributor than does curve B. Curve A is shown as lying slightly above curve B, but it is doubtful if the difference is significant. Since the curves should pass through the origin, an average straight line drawn from the origin through all the points shown would intersect the 100% operating line at a benzene flow rate of about 0.10 cu. ft./(hr.)(nozzle). This corresponds to a linear velocity of 10 cm./sec. The linear relation yields the important conclusion that as the dispersed-phase flow is increased, new nozzles come into operation to maintain the linear velocity of the fluid in the nozzles already operating at about 10 cm./sec. This continues until all the nozzles are functioning. The pulsing type of individual drop production prevails throughout this range. Further increase in the dispersed-phase flow increases the linear velocity in the nozzles beyond this value, and when a velocity of about 13 cm./sec. is reached, production of droplets from jets ensues.

DROP SIZE

The drop-size data are presented graphically in Figures 8 and 9. Comparison of the two figures shows, in the first place, that a decrease in drop size takes place with an increase in benzene temperature at the distributor. This is likely due to the direct effect of temperature on the interfacial tension with the resultant effect on drop size. Second, the continuous-phase rate has no noticeable effect on drop size. This permits an important extension of the correlation of Hayworth and Treybal (*8*) for predicting drop sizes, since the work reported by these investigators was carried out with a single nozzle and a stagnant continuous phase. A graphical comparison of the equivalent drop diameters obtained in the runs of the present study with those predicted by the Hayworth-Treybal correlation is presented in Figure 10.

Since the drops produced in this study were obtained under nonisothermal conditions, the density difference term in the Hayworth-Treybal correlation was calculated by using the density of each phase at its own particular temperature in the vicinity of the distributor and taking this difference. In evaluating the interfacial tension, the temperature taken was the average of the two bulk temperatures.

An inspection of Figure 10 shows that the agreement between the observed diameters and those calculated from the Hayworth-Treybal correlation is good. A study of the data reveals that this is particularly true at nozzle velocities below 10 cm./sec., where the experimental values are within 0.02-0.03 cm. of the calculated values, being consistently lower. At nozzle velocities much in excess of 10 cm./sec., the difference increases to 0.05-0.06 cm. This can be explained readily by the fact that Hayworth and Treybal found nonuniformity of drop size to become pronounced at nozzle velocities above 10 cm./sec. and correlated only the largest drop size present in the mixture; data obtained here represent the average drop size in all cases. It may be of interest to note that the nozzle velocity characterizing the transition of uniform to nonuniform drop production in the Hayworth-Treybal investigation

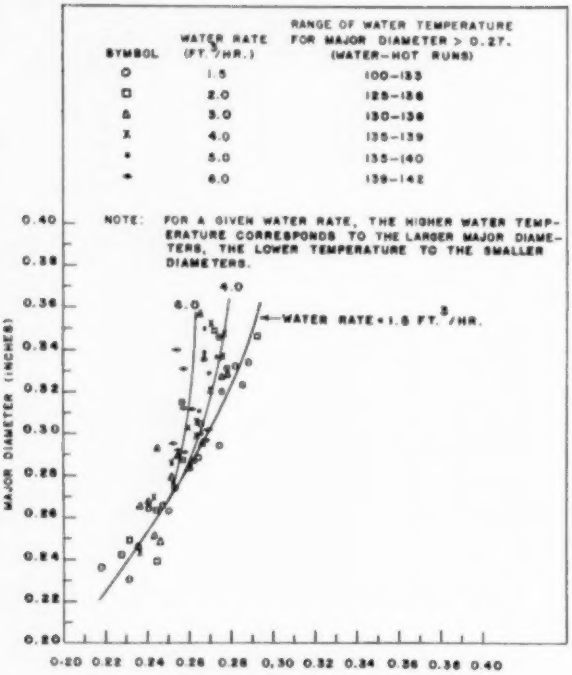


Fig. 11. Major vs. minor drop diameters.

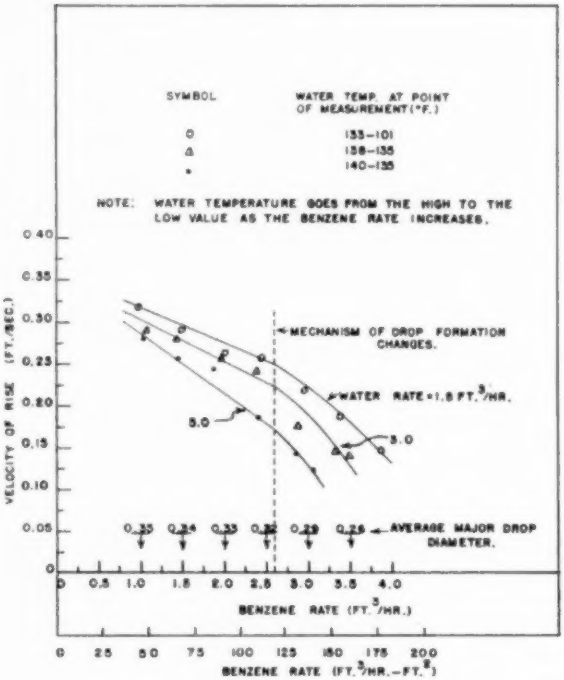
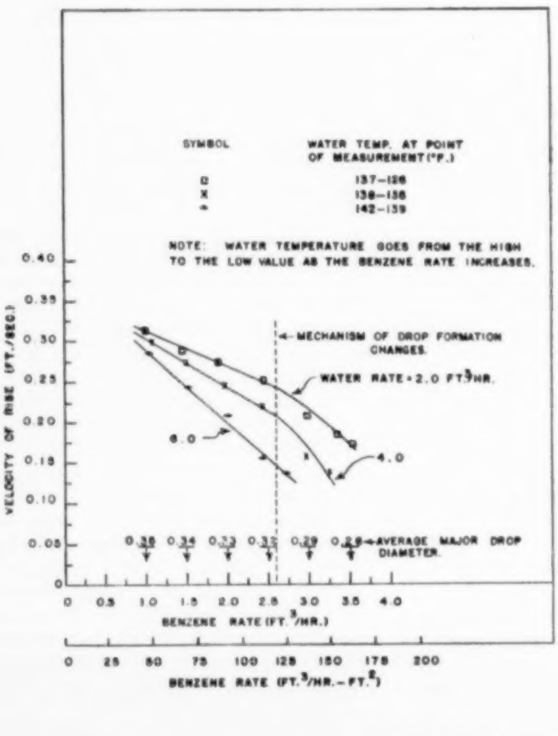


Fig. 12. Velocity of rise—hot water runs.

coincides fairly well with the average nozzle velocity below the point of 100% distributor operation in this study. There is also a coincidence with the transition of pulsing to "jet"-type production. It is interesting to note, too, that the difference between Hayworth-Treybal diameters and those observed in this study occurred in most cases when the pulsing type of drop formation changed to the jet type.

Although an increase in the continuous phase rate has no effect on the average size of the drop, it appeared to have a slight effect in flattening out the drop, particularly in the larger sizes. This is shown in Figure 11. A direct connection may not exist for variations in



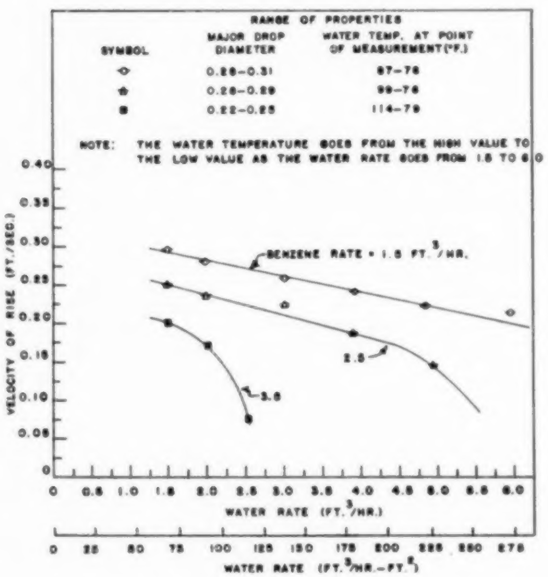


Fig. 13. (Left) Velocity of rise—hot water runs.

Fig. 14. (Right) Velocity of rise—hot benzene runs.

water temperature complicate the picture. A higher water temperature prevailed in those runs where larger benzene drops were produced. This would tend to lower the interfacial tension and cause the drop to flatten out.

VELOCITY OF RISE

Data on the velocity of rise of the drops are shown graphically in Figures 12-15. As expected, the velocity of rise decreases with increasing water rate and decreasing drop size. The decrease in velocity of rise with increasing benzene rate appears to result directly from an increase in the number of drops, and indirectly from a reduction in drop size.

HOLDUP

The velocity of rise and holdup data are summarized in smoothed graphical form in Figure 16. The plot shows the velocity of rise to decrease and the holdup to increase with increasing water rate at constant benzene rate. At low benzene rates the effect on the holdup is small and that on the velocity of rise great; at high benzene rates, the reverse is true. The same general effect is found when the water rate is held constant; the velocity of rise decreases and holdup increases with increasing benzene rate.

LIMITING VELOCITIES

Figure 17 shows a semilogarithmic plot of the flooding data obtained. The discontinuous phase rate is plotted logarithmically and the continuous phase rate on a rectangular scale. It has been found (*4*) that such a plot is frequently a straight line, and that one of the factors which determines the location of the line is the viscosity of the continuous phase. Figure 17 shows that a straight line is obtained for the water-to-benzene transfer runs where the continuous-phase temperature in the neighborhood of the distributor remained fairly constant between 112 to 131° F. Temperatures of the water in the benzene-to-water transfer runs varied from 88-141° F., and a curved line results in this case.

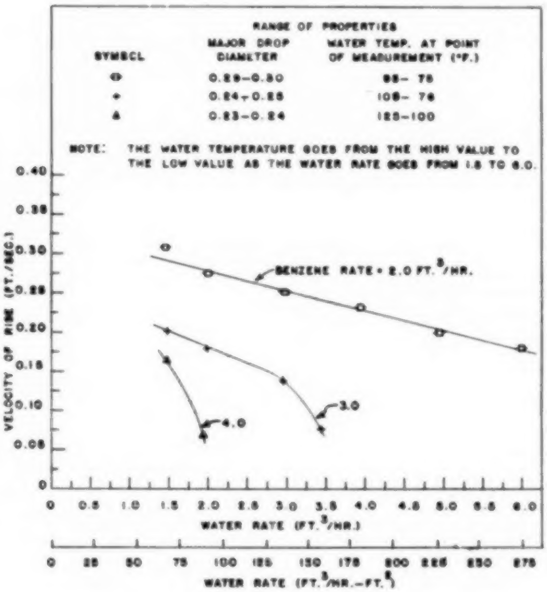


Fig. 15. Velocity of rise—hot benzene runs.

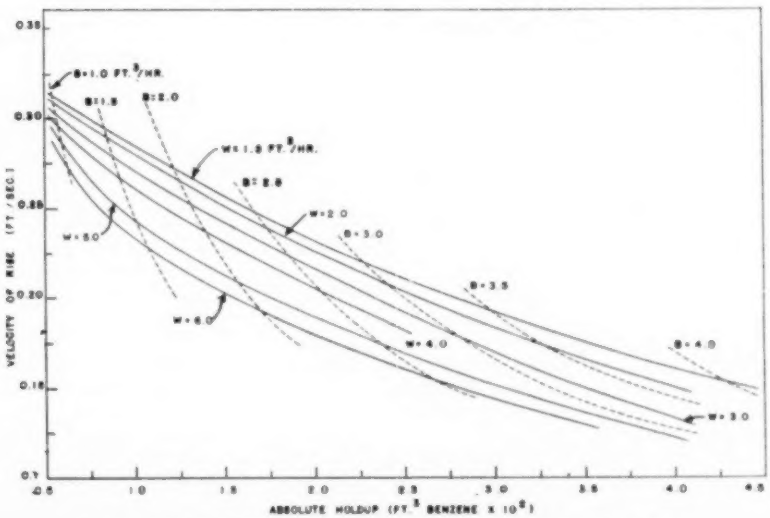


Fig. 16. Velocity of rise, holdup and flow rate relationships—smoothed data.

HEAT-TRANSFER COEFFICIENTS

A comparison of U_{rig} and U_{lm} is of interest. U_{rig} was not calculated for some of the runs because of a variety of reasons: incomplete data for the continuous phase temperature-length plot, a poor plot of a complete set of temperature data, or a poor heat balance. The $U_{rig}:U_{lm}$ ratio for the runs calculated is shown graphically as a function of column holdup in Figures 18 and 19. It will be shown that holdup can be satisfactorily used to correlate the heat-transfer coefficients.

There seems to be an increase in the ratio $U_{rig}:U_{lm}$ as the holdup increases, the value being a little less than unity at low holdups, and increasing to approximately 1.2 at high holdups. High holdups result from high flow rates, and the behavior of the ratio may provide some evidence for increased recirculation of the liquids at high flow rates. Recirculation of the liquids would bring about a decrease in true countercurrent contact (part of the contact taking place concurrently). As in the case of multipass heat exchangers, this means a reduction in the driving force relative to the logarithmic-mean value, or, correspondingly, an increase in rigorous heat-transfer coefficient relative to the logarithmic-mean *U*. Certainly, if heat loss were the responsible factor here, the discrepancy between the two *U*'s would be the least at the high rates, where the heat loss represents a smaller fraction of the heat transferred between the phases.

Further discussion will be limited to logarithmic-mean coefficients since these are easily calculated and, once known, easily employed in the reverse process of obtaining areas in a design. Also,

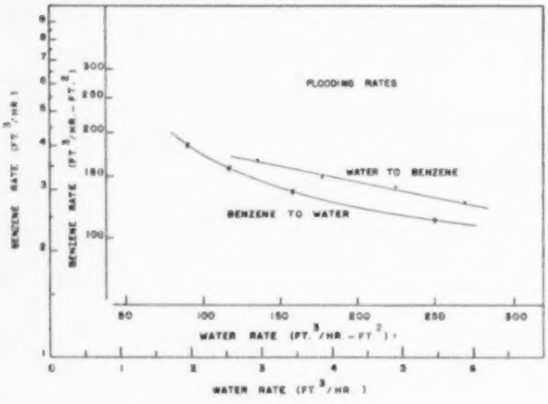


Fig. 17.

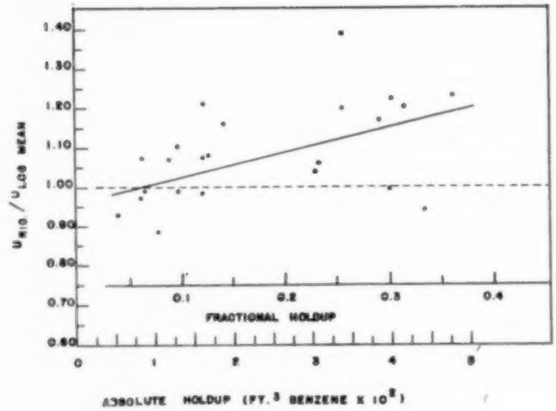
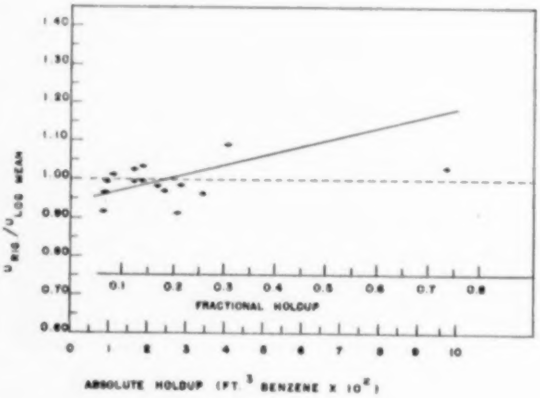
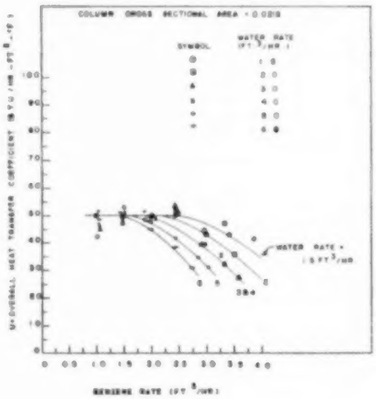


Fig. 18. Ratio of *U*'s vs. holdup—hot water runs.



◀ Fig. 19. Ratio of *U*'s vs. holdup hot benzene runs.

Fig. 20. U_{lm} vs. dispersed phase rate—hot water runs. ▶



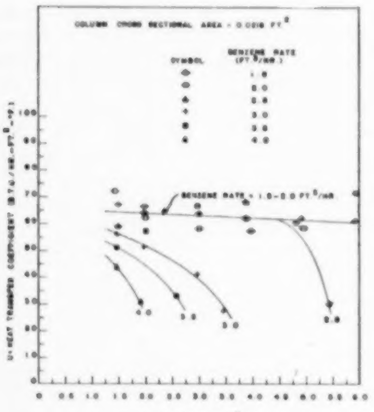


Fig. 21. U_{lm} vs. continuous phase rate—hot benzene runs.

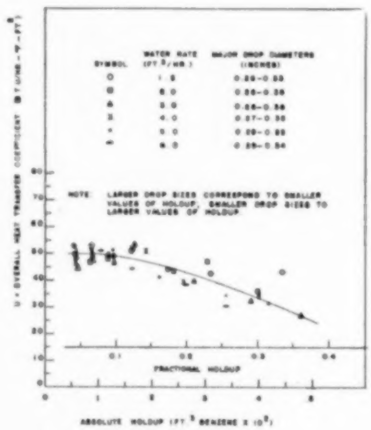


Fig. 22. U_{lm}-holdup correlation—hot water runs.

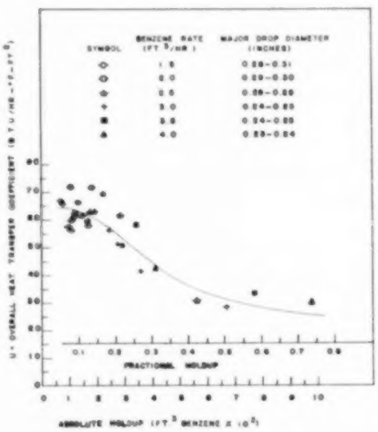


Fig. 23. U_{lm}-holdup correlation—hot benzene runs.

the effect of variables to be discussed should be essentially the same on both U_{lm} and U_{rig}.

Figures 20 and 21 show the effect on U of an increase in discontinuous- and continuous-phase rate respectively. Curves of Figure 20 are brought together as one curve in Figure 22, where the U is plotted vs. holdup. In a similar fashion, the various curves of Figure 21 appear as a single holdup curve in Figure 23.

The figures show that at low values of holdup (low, continuous and discontinuous phase rates) the heat-transfer coefficient appears to be fairly constant. It then drops off noticeably at high holdups. This falling off effect exists, although it is not as pronounced, when U_{rig} is plotted instead of U_{lm} (*see* Fig. 24). It is reasonable to suppose that masking of some of the surface because of crowding of the droplets may be responsible for the falling off of U,

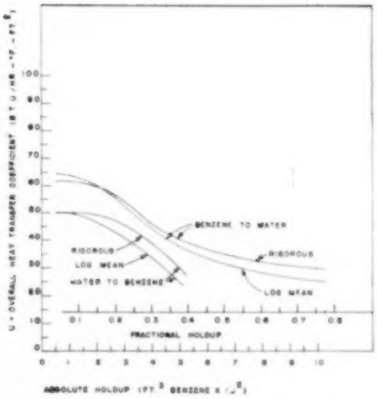


Fig. 24. Sumary plot of U vs. holdup.

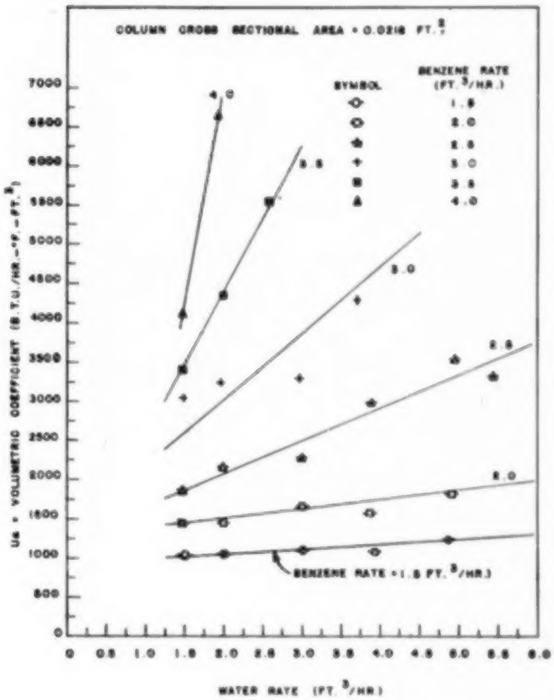
since the total interfacial area is used in the calculation. Also, a condition of hindered rising of the droplets prevails at high holdups, and this reduction in the relative velocity of the fluids may account directly for the reduction in U. The transfer is more rapid when heat flows from the discontinuous to the continuous phase than when the reverse is true. The reason for this is not clear. The difference is of the order of 25 to 30%. Graphs are shown together for comparison in Figure 24. Values of U at low holdups (in the absence of presumed area masking) are in the neighborhood of 50-60 B.t.u./(hr.)-(sq.ft.)(°F.). These are roughly what might be expected for heat transfer in this system for the condition of one fluid moving past the interface, the other being relatively stagnant in this respect.

Volumetric coefficients, expressed as B.t.u./(hr.)(cu.ft.)(° F.), are shown in Figures 25 and 26. As expected, these increase rapidly with increase in flow rate of either phase, reflecting the considerable increase in interfacial area which occurs.

Data on the end effect at the bottom of the column (dispersed-phase distributor section) are plotted in Figures 27 and 28. There seems to be an end effect (improvement in heat transfer) at the dispersed-phase distributor when heat transfer takes place from the continuous to the discontinuous phase, but none when the transfer takes place in the opposite direction. The end effect cannot be attributed to a higher local coefficient in this portion of the column as a result of different temperature levels within the column, for the bottom of the column was the low temperature end in the hot water runs, and this would tend to give low results instead of high ones.

No attempt was made to determine the possible existence of an end effect at the coalescence section of the column because of the small driving force existing there.

Fig. 25. Volumetric coefficients—hot benzene runs.



Notation

a = interfacial surface per unit volume, sq.ft./cu.ft.
a' = heat-transfer area per unit column length, sq.ft./ft.
A = heat-transfer area, sq.ft.
A_d = area per drop, sq. ft.
B = benzene flow rate, cu.ft./hr.
C = specific heat, B.t.u./(lb.)(°F.)
D_j = major drop diameter, in.
D_m = minor drop diameter, in.
d_1 = nozzle diameter, ft.; specifically, 0.0104 ft.
H_{abs} = absolute benzene holdup, cu.ft.
H_{fr} = fractional benzene holdup
L_e = effective column length, ft.; specifically, 6.08 ft.
M = rate of mass flow, lb./hr.
n_t = number of distributor nozzles in operation
Q = rate of heat transfer, B.t.u./hr.
S = column cross-sectional area, sq.ft.; specifically, 0.0218 sq.ft.
t = temperature, °F.
Δt = temperature difference, °F.
U = heat-transfer coefficient, B.t.u./(hr.)(sq.ft.)(° F.)
v = drop velocity of rise, ft./sec.
v_t = average linear velocity of benzene through distributor nozzles, ft./sec.
v_t' = average linear velocity of benzene through distributor nozzles, cm./sec.
V_d = volume per drop, cu.ft.
W = water flow rate, cu.ft./hr.
Z = distance from top of column, ft.

Subscripts

a = air
$avg.$ = average
b = benzene
w = water
L = loss to outside air
$number$ = designates location in column
rig = rigorous
lm = logarithmic mean

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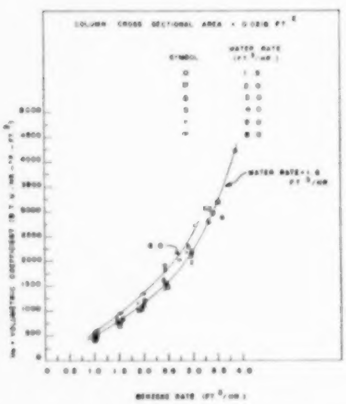

Fig. 26. Volumetric coefficients—hot water runs.

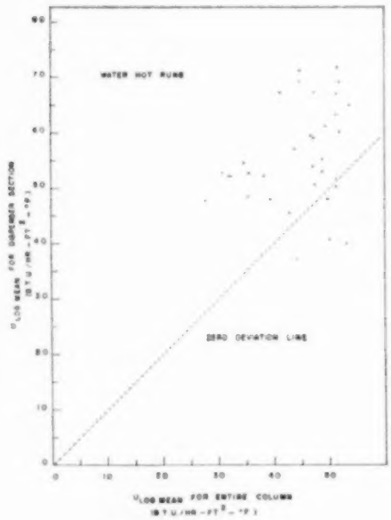

Fig. 27. End effect data.

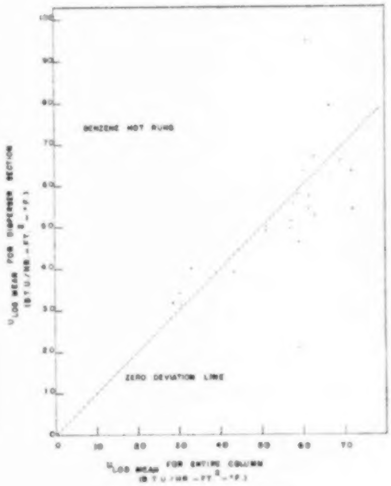

Fig. 28. End effect data.

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Presented at A.I.Ch.E. Forty-fifth annual meeting, Cleveland, Ohio.

Pressure Effects on Vaporization Rate of Drops in Gas Streams

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Abstract of a paper published in pamphlet form by National Advisory Committee for Aeronautics as Technical Note 2850. Obtainable from N.A.C.A., Washington, D. C.

The determination of the rate of vaporization of a pure liquid from a spherical surface exposed to a gas stream of varying static pressure required the use of the heat-balance equation

$$\frac{dm}{d\theta} = \frac{hA}{H_v}\Delta t$$

where $dm/d\theta$ is the vaporization rate, h is the heat-transfer coefficient, A is the surface area of the drop, H_v is the latent heat of vaporization, and Δt is the difference between the gas temperature and the surface temperature of the drop. Sensible heat transferred by the liquid was negligible in comparison with latent-heat requirements.

Experimental data were obtained for four pure liquids tested over an air-stream static-pressure range of 450 to 1,500 mm. of Hg. Data were also obtained for methanol evaporating in constant-pressure streams of helium, argon, and carbon dioxide. The following semiempirical equation for predicting the evaporation rate of a drop was determined:

$$\frac{dm}{d\theta} = \frac{k_g\Delta t}{H_v}2\pi d\left[1 + 1.29\times 10^6\left(ReSc\,\frac{gl}{c'^2}\right)^{0.6}\left(\frac{k_g}{k_v}\right)^{0.5}\right]$$

where k_g and k_v are the thermal conductivities of the gas and the vapor, respectively, d is the drop diameter, Re and Sc are the Reynolds and Schmidt numbers, respectively, g is the acceleration due to gravity, l is the mean free path of the gas molecules, and c' is the root-mean-square velocity of the gas molecules. This expression was obtained for the case of isolated drops and a low value of approach-stream turbulence.

The evaporation-rate and the surface-temperature data obtained in this study show the heat-transfer coefficient to be independent of the static pressure of the system, and the effect of pressure on the vaporization rate to be determined directly by the effect of pressure on the surface temperature of the drop. An equation is also presented for calculating the Δt value for water at a static pressure of 450 to 1,500 mm. of Hg by use of the Δt value for 1-atm. pressure and a calculated correction term $\Delta t'$.

Presented at A.I.Ch.E. Forty-fifth annual meeting, Cleveland, Ohio.

Kinetics of Catalytic Cracking of Cumene

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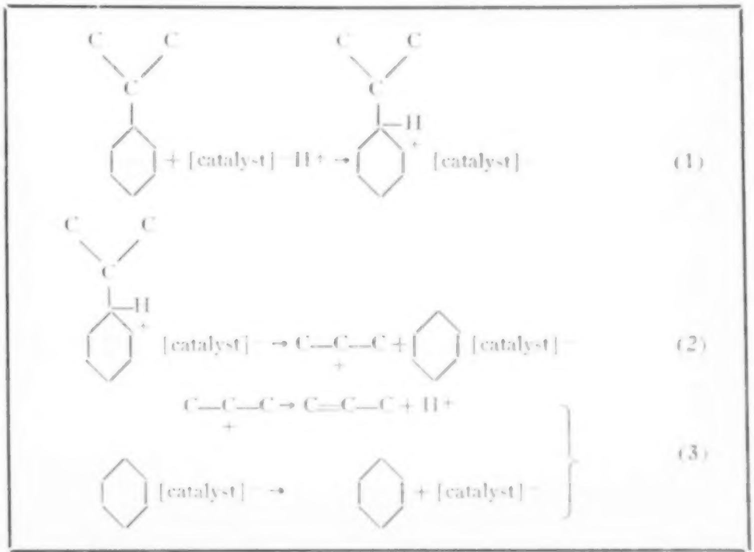
This paper reports the results of an investigation of cracking cumene over a silica-alumina catalyst. A small fixed-bed integral reactor was used. Data for conversion vs. reciprocal space velocity curves were obtained at three temperatures, 850, 950, and 1050° F.

Results show that catalytic cracking takes place by a single-site, surface-reaction controlling mechanism. The kinetic rate constant and adsorption constants for cumene and benzene are reported as functions of temperature.

The effectiveness factor, or effect of particle size, was also investigated. For this reaction it was shown that silica-alumina catalyst has a low effectiveness factor, i.e., that only a thin skin on the exterior of the particle is catalytically effective.

This project was an investigation of the kinetic mechanism of cracking cumene (isopropylbenzene) over a silica-alumina catalyst. The effectiveness factor, E, the effect of catalyst particle size, was also determined. A general study of the cracking reactions was undertaken because of their industrial importance. Cumene was chosen because its cracking reaction is clean, producing benzene and propylene, with negligible quantities of by-products.

Thomas et al (*11, 12*) and Greensfelder et al (*4*) studied the cracking of various alkylbenzenes, including cumene, over a silica-alumina catalyst, reporting products and yields. These authors concluded that cracking took place by a carbonium ion mechanism, as silica-alumina catalyst is acidic in nature. This mechanism may be illustrated by Equations (1), (2) and (3).



The experimental work was directed toward determining the rate-controlling step, its rate equation, and the effect of catalyst particle size.

At present Mr. Corrigan is associated with Mathieson Chemical Corp., Niagara Falls, N. Y., and Mr. Rase with the University of Texas, Austin, Tex.

For complete tabular data, order document 4065 from A.D.I. Auxiliary Publications Photoduplication Service, Library of Congress, Washington 25, D. C., remitting $1.25 for microfilm (images 1 in. high on standard 25-mm. motion-picture film) or $1.25 for photoprints readable without optical aid.

Apparatus

A flow diagram of the apparatus is given in Figure 1. Compressed nitrogen from a commercial cylinder was used to force the feed from Tanks T-1 or 2 through a rotameter (RM-1) and thence to the reactor (R-1). Flow rates were adjusted by means of a needle valve and a rotameter and measured by changes in tank level, observed with the graduated sight glasses, GG-1 and 2. All feed, nitrogen, and air lines were constructed of ¼-in. copper tubing with flared fittings.

The reactor was constructed from a 27% Cr stainless steel tube, 0.807 in. I.D. × 4 ft.-11 in. long, enclosed by six 5⅜-in. diam. × 6 in. × 1¼ in. bore Ampco metal blocks which were each surrounded by No. 506-SP, 115 v., 850 w. Heavi-Duty heating elements. Each section was insulated with 2 in. of rock wool and encased in a sheet metal shell. The inside of the reactor tube, except for the catalyst space, was filled with removable metal plugs. Various lengths of plugs were available so that the size and location of the catalyst bed could be varied. The plug in the upper or preheater section had spiral grooves which provided efficient contact of the feed with the hot reactor wall. The plugs below the catalyst bed were of slightly smaller diameter than the inside of the reactor to permit passage of the products. Catalyst was supported on a perforated stainless steel plate which was attached to the uppermost plug in the lower section. Stainless steel thermocouple wells (0.180-in.O.D.) extended through packing glands in the bottom and top of the reactor to the bottom and top of the catalyst bed respectively.

Three separate 110-v. electric circuits were used for heating the reactor. One served the bottom three blocks; a second, the top block, and a third, the two intermediate blocks. Satisfactory temperature control was accomplished by manual operation of the 18 amp. Variacs in these circuits. The two temperature controllers (TC-1 and 2) were used only as safety devices to avoid overheating. These operated by means of differential expansion between the reactor block and a silica rod inserted in the block.

Reactants and unreacted feed passed from the reactor through a hand control valve (HCV-1), used for controlling reactor pressure, and thence to an ice-water cooled condenser (C-1). Liquid product was collected in this condenser during the run. Product gas passed from the condenser through a wet test meter (WTM-1), and then to the vent or the gas-sampling bottle.

A Brown, twelve-point, high-speed, Electronik, strip chart temperature recorder (TR-1) was used to record temperature at the points indicated on Figure 1. The reaction temperature was taken as the average of the top and bottom catalyst bed temperatures. The difference between these two temperatures varied from 0 to 25° F., depending on the conversion level.

Catalyst

The catalyst was obtained from a single batch of T.C.C. silica-alumina cracking catalyst manufactured and donated by the Socony-Vacuum Corp. Three bead sizes were separated, $-6+8$, $-4+6$ and $-3+4$ Tyler-mesh size. A fourth size $-28+35$ mesh was obtained by grinding $+4$ mesh beads in

Table 1.—Catalyst Properties

Catalyst No.	Mesh	a_m Surface Area/Unit Mass (cm.)²/g.	D_p Equivalent Diam. cm.	Bulk Density g./cc.	Particle Density g./cc.	Real Density g./cc.	Void Fraction (external)	Void Fraction (total)
1	$-28+35$	118	0.045	....	1.14*	....	....	....
2	$-6+8$	16.1	0.33	0.676	1.137	2.26	0.41	0.84
3	$-4+6$	12.3	0.43	0.685	1.149	2.37	0.41	0.85
4	$-3+4$	10.0	0.53	0.672	1.143	2.33	0.41	0.85

Total surface area: 342 sq.m./g.

* Assumed.

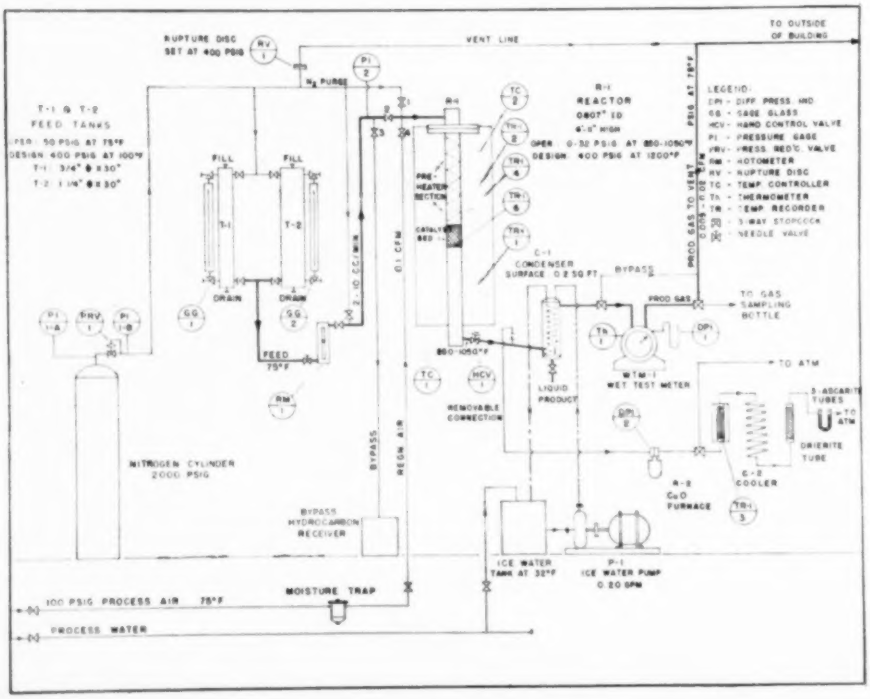


Fig. 1. Flow diagram.

a cast-iron mortar and pestle, using sharp, hammer-like blows rather than attrition. The $-4+6$ mesh sample was used for the mechanism study. All four samples were employed in the study of effectiveness factors and catalyst size effects.

Physical properties of each sample are presented in Table 1. Particle densities were determined with a pycnometer using mercury as the fluid. The true solid density was determined in the same manner but water was employed as the fluid. The beads were soaked for 12 hr. in water. Helium densitometer measurements as described by Pufahl (*8*) were also made and these satisfactorily checked the results obtained with water.

The surface areas of the particles were calculated from the pycnometric determinations made with mercury. From the volumes of the pycnometer and the mercury and the number of particles, the surface area and diameter of each particle was calculated assuming a spherical shape. The surface area of the ground sample was determined from statistical diameter measurements, employing a photomicrographic camera and the methods of Heywood (*5*). A shape factor of 10.5 was used for these particles.

Feed Stock

Dow Chemical Co. Technical Grade isopropylbenzene was used after first being redistilled in a 30-plate (26 mm. diam.) Oldershaw distillation column at 20:1 reflux ratio.

Experimental Procedure and Analysis

The runs were of 20-min. duration with the product from the first 5 min. being discarded and that from the final 15 min. being saved for analysis. In a preliminary investigation of this reaction Corrigan (*1*) found from runs of one-hour duration that the decrease in catalyst activity with process time was quite small. Thus it was possible to assume that the average conversion for a 15-min. run was the same as that which would be obtained on a clean catalyst.

The feed rate was controlled manually with the needle valve at the flowrator inlet, the reactor temperature by adjusting the voltage to the heating units, and the reactor pressure by manual operation of the needle valve at the outlet of the reactor. The liquid product was collected in the bottom of the condenser while the uncondensed material (mostly propylene) passed through a wet test meter and was vented. In a few of the early runs gas samples were collected and analyzed. All these samples ran over 90% unsaturates.

Following each run the system was purged with nitrogen and the carbon deposit burned off the catalyst with either air or oxygen. In all cases the regeneration was begun at the reaction temperature. Because of the small carbon deposits obtained, no difficulty was experienced in controlling the temperature rise on regeneration. Successive runs gave identical results, showing that the regeneration procedure returned the catalyst to the same activity level.

The conversion for each run was determined by analysis of the liquid product for benzene. This analysis was performed by distillation in either a high-temperature Podbielniak column or a Piros-Glover microstill. Two or three successive runs were made at each pressure and temperature; the products from these runs were combined into one sample which was then analyzed. Duplicate sets of runs were frequently made as checks on accuracy. This procedure tended to average any random variation in catalyst activity which might occur from run to run.

From time to time, a standard run (950° F., 1 atm.) was repeated. The resulting conversions were always in agreement, proving that the activity of the catalyst was essentially constant during the period of experimentation.

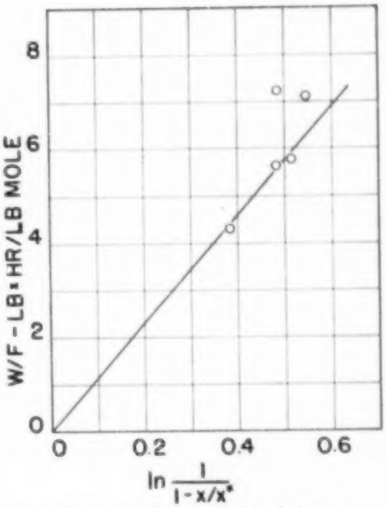


Fig. 2. Pseudo first-order plot of data at 950° F., 4.27 atm.

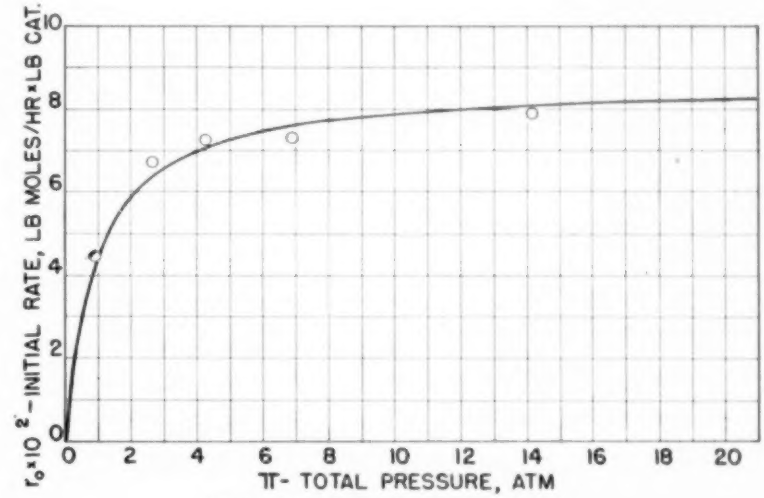


Fig. 3. Initial rate vs. total pressure at 950° F.

Selection of Reaction Mechanism, Evaluation of Constants

The effects of diffusion and thermal cracking were evaluated first to determine whether they would complicate the correlation. Preliminary calculations utilizing the methods of Yang and Hougen (*13*) indicated that mass-transfer effects were negligible at the space velocities used. Experimental data obtained by varying the mass velocity of the feed at constant space velocity confirmed these calculations. The amount of thermal cracking was determined by passing the cumene over a bed of quartz chips in the reactor. At the temperatures employed, thermal cracking was negligible.

The apparent kinetic mechanism for the dealkylation of isopropylbenzene was selected according to the methods outlined by Hougen and Watson (*7*) and by Yang and Hougen (*13*). Their methods involved consideration of the effect of the total pressure on the initial rate, the rate at 0% conversion.

Either a single-site or a dual-site mechanism can be postulated for this reaction as follows:

Single-site

a. $A + l \rightleftarrows Al$

b. $Al \rightleftarrows Rl + S$

c. $Rl \rightleftarrows R + l$ (4)

Dual-site

a. $A + l \rightleftarrows Al$

b. $Al + l \rightleftarrows Rl + Sl$

c. $Rl \rightleftarrows R + l$

d. $Sl \rightleftarrows S + l$ (5)

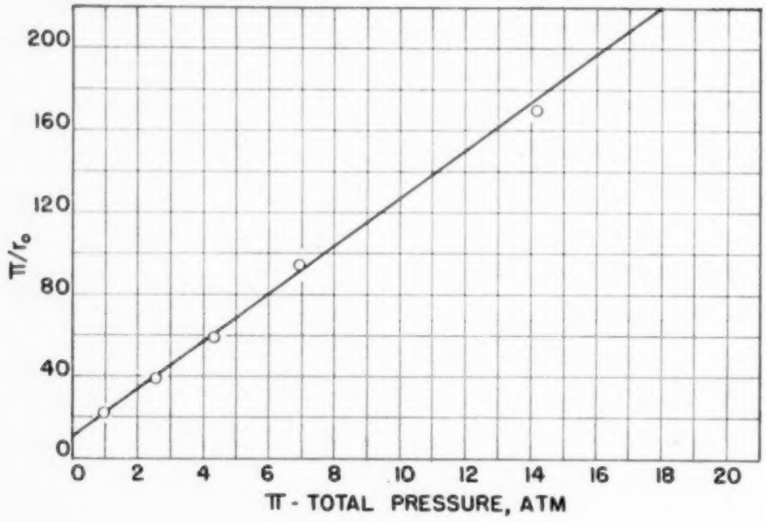


Fig. 4. π/r_o vs. π at 950° F.

where

A represents cumene
R represents benzene
S represents propylene
l represents an active catalyst site

From these two series of reactions, seven possible mechanisms can be postulated by considering each step in turn to be rate-controlling. The seven possible mechanisms are thus:

a. Single-site reaction with adsorption of *A* controlling
b. Single-site reaction with surface reaction controlling
c. Single-site reaction with desorption of *R* controlling
d. Dual-site reaction with adsorption of *A* controlling
e. Dual-site reaction with surface reaction controlling
f. Dual-site reaction with desorption of *R* controlling
g. Dual-site reaction with desorption of *S* controlling

Following the procedures outlined in the above references, expressions can be written for the initial rate, r_o, in terms of total pressure for each of the proposed mechanisms. These expressions reduce to four general cases as follows:

For single-site and dual-site desorption of either product controlling

$$r_o = \frac{ELk}{K_R} \text{ or } \frac{ELk}{K_S} = a \tag{7a}$$

For single- and dual-site adsorption controlling

$$r_o = ELk\pi = a\pi \tag{7b}$$

For single-site surface-reaction controlling

$$r_o = \frac{ELkK_A\pi}{1 + K_A\pi} = \frac{a\pi}{1 + b\pi} \tag{7c}$$

For dual-site surface-reaction controlling

$$r_o = \frac{ELkK_A\pi}{(1 + K_A\pi)^2} = \frac{a\pi}{(1 + b\pi)^2} \tag{7d}$$

where *a* and *b* are suitable groupings of the constants ELk, K_A, K_R, and K_S.

The initial rates, r_o, were calculated from pseudo first-order plots of the data (Fig. 2). Hougen and Watson (7) state that even complex catalytic reactions approximate first-order behavior at constant pressure and low conversions where the effects of reaction products are negligible. The integrated pseudo first-order equation is

$$W/F = \frac{x^*}{r_o} \ln \frac{1}{1 - x/x^*}$$

From the plot of r_o vs. π obtained at 950° F. (Fig. 3), it is obvious that neither adsorption- nor desorption-controlling mechanisms are possible. Similar curves were obtained at the other temperatures. It is not possible, however, to decide immediately between a single-site and a dual-site surface-reaction controlling mechanism.

From Equations *7c* and *d*, it can be seen that for a single-site mechansm, r_o increases and finally reaches a constant value as π increases, while for a dual-site mechanism r_o reaches a maximum and then approaches zero as π increases.

In the case of the dual-site mechanism, the pressure at which r_o reaches a maximum is equal to $1/K_A$. This is determined by differentiating Equation (*7d*) with respect to π, equating the derivative to zero, and solving for π.

If Equations (*7c*) and (*7d*) for the surface-reactions controlling are rewritten in terms of π/r_o, (using k' and K_A' for the dual-site equation), a relationship between K_A and K_A' may be developed as follows:

For single-site surface-reaction controlling

$$\frac{\pi}{r_o} = \frac{1}{ELkK_A} + \frac{\pi}{ELk} \tag{8a}$$

For dual-site surface-reaction controlling

$$\frac{\pi}{r_o} = \frac{(1 + K_A'\pi)^2}{ELk'K_A'} \tag{8b}$$

From these equations it can be seen that a plot of π/r_o vs. π would give a straight line for the single-site mechanism and a parabola for the dual-site. Figure 4 shows that the data are essentially linear, and if the dual-site mechanism is valid, the straight line and the parabola must coincide over this range of data.

For the single-site Equation (*8a*), the slope $m = 1/ELk$, and the intercept, $b = 1/ELkK_A$, and $K_A = m/b$.

The derivative (with respect to π) of Equation (*8b*) when evaluated at $\pi = 0$, gives the initial slope of the parabola which is equal to the slope *m* of the straight line for the single-site equation.

$$\left[\frac{d(\pi/r_o)}{d\pi}\right]_{\pi = 0} = m = \frac{2}{ELk'}$$

The value of π/r_o at $\pi = 0$, the intercept of Equation (*8b*), is identical with the intercept of Equation (*8a*). Then $b = 1/ELk'K_A'$. Solving for K_A',

$$K_A' = \frac{1}{ELk'b} = \frac{1}{2}\frac{m}{b}$$

Thus $K_A' = 1/2\ K_A$.

Then the value of K'_A for the dual-site mechanism is one-half that of the single-site mechanism. It is more convenient to fit the best straight line through the data rather than a parabola. This was done by the method of at least mean squares. Thus K_A can be evaluated for the single-site mechanism and from this, K_A' for the dual-site mechanism can be calculated. The values of K_A for both mechanisms at 850, 950, and 1050° F. are tabulated in Table A, together with the value of π at which r_o should be a maximum if the dual-site mechanism is valid. It will be seen from Figure 3 that r_o continues to increase beyond these values of π; therefore the dual-site mechanism is not valid. Data at 850 and 1050° F. give similar curves, with r_o increasing beyond the pressure at which a maximum should occur.

Table A.

Temp. ° F.	K_A = single site	K_A' = dual site	$\pi = \frac{1}{K_A'}$ (atm.)
850	1.46	0.73	1.37
950	1.07	0.54	1.86
1050	0.82	0.41	2.44

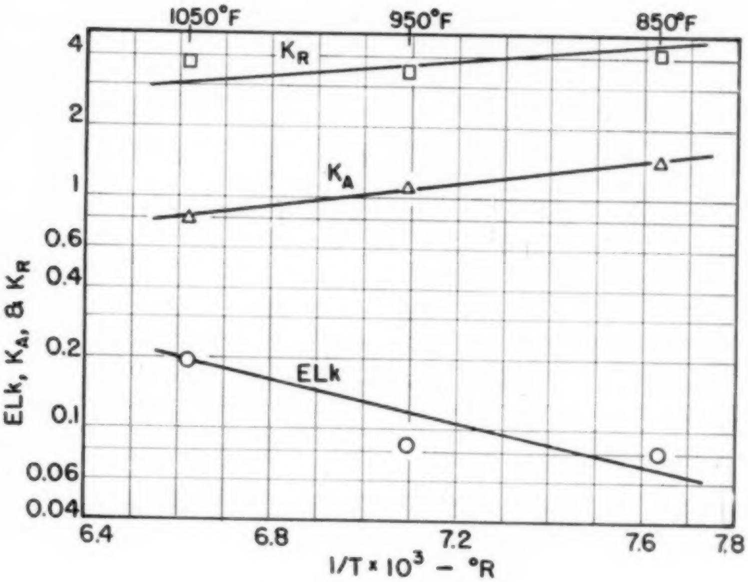


Fig. 5. ELk, K_A, and K_R vs. $1/T$.

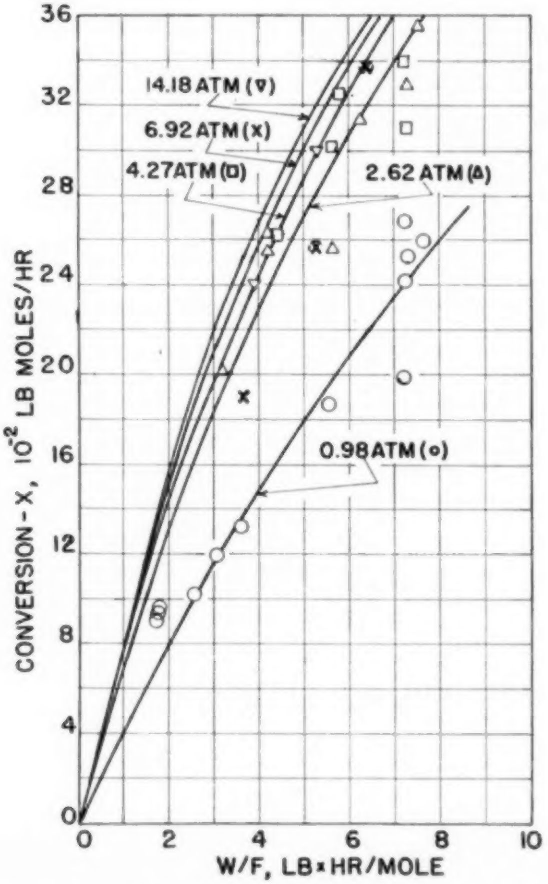


Fig. 6. Comparison of calculated curves with experimental data at 950° F.—X vs. W/F.

As outlined above, the values of ELk and K_A were evaluated from plots of π/r_o vs. π at 850, 950, and 1050° F.

As the mechanism of this reaction is a single-site surface reaction, only one of the products may be adsorbed. It is reasonable to assume that benzene is adsorbed preferentially to propylene. Further, the carbonium ion theory mentioned previously postulates that the propylene would not be adsorbed as a step in the reaction. Data on runs with mixed feeds of cumene and benzene indicate this assumption is correct.

The rate equation for the single-site, surface-reaction controlling mechanism is

$$r = \frac{ELkK_A(p_A - p_R p_S/K)}{1 + K_A p_A + K_R p_R} \tag{9}$$

where

r = rate, lb. moles of benzene formed/(hr.)(lb. catalyst)

E = effectiveness factor

L = number of molal active sites/lb. of catalyst

k = reaction velocity constant

K_A = adsorption constant for cumene

K_R = adsorption constant for benzene

p_A = partial pressure of cumene, atm.

p_R = partial pressure of benzene, atm.

p_S = partial pressure of propylene, atm.

The adsorption constant for benzene, K_R, was evaluated by substituting experimental data in the integrated rate equation, which is as follows:

$$\frac{W}{F} = \gamma\left[\left(\frac{1}{2\delta} - \frac{1}{2\delta^3}\right)\ln\frac{1+\delta x}{1-\delta x} + \frac{x}{\delta^2}\right] + \beta\left[\frac{1}{2\delta^3}\ln\frac{1+\delta x}{1-\delta x} - \frac{1}{2\delta^2}\ln(1-\delta^2x^2) - \frac{x}{\delta^2}\right] \tag{10}$$

where

$$\gamma = \frac{1}{ELkK_A\pi} + \frac{1}{ELk}$$

$$\beta = \frac{2}{ELkK_A\pi} + \frac{K_R}{ELkK_A}$$

$$\delta = \frac{1}{x^*} = \sqrt{1 + \pi/K}$$

x^* = equilibrium conversion

K = thermodynamic equilibrium constant for over-all reaction

It was found that the reverse reaction was negligible and could be ignored.

For this case, Equation (10) reduces to:

$$\frac{W}{F} = \gamma x + \beta[-\ln(1-x) - x] \quad (11)$$

K_R was evaluated from Equation (11) by plotting $(W/F - \gamma x)$ vs. $[-\ln(1-x) - x]$. The best straight line was then drawn through the points; the slope of this line was β, from which K_R could be calculated.

Values of K_R reported are somewhat uncertain. This is due to the majority of data being obtained at low conversions, where the effect of the reverse reaction and the adsorption of benzene were negligible. Low-conversion data, however, are essential for the selection of the mechanism. Runs made at higher conversions showed that secondary and side reactions introduced sufficient uncertainty that values of K_R calculated from these runs would not be more accurate.

These constants are plotted as functions of temperature in Figure 5.

The x vs. W/F curves calculated from the integrated Equation (11), using the constants reported in Figure 5 are shown for 950° F. in Figure 6, together with the experimental data. It will be seen that there is fair agreement between the experimental data and the calculated curve at lower pressures. At higher pressures, it is believed that considerable fouling takes place, effectively lowering the conversion, and thus causing the experimental points to be displaced below the calculated curves.

Effect of Catalyst Size

The effectiveness factor, defined by Thiele (*10*) as the ratio of the actual rate of reaction per unit mass of catalyst to the rate which would exist if the concentrations at all interior interfaces were the same as those at the gross exterior interface, provides a method for introducing the effects of catalyst size and porosity into the rate equation.

Where a catalyst of constant and uniform effectiveness is used, its numerical value may be ignored by including it in the over-all rate constant as ELk. However, it is well to know the magnitude of E, for a value far from unity can obscure the significance of the empirically determined constants in the rate equation. At high values of effectiveness factors (approximately 0.85 to 1.0), it can be assumed that resistance to diffusion to and from the catalyst interior is negligible. At low effectiveness factors (approximately 0-0.3) the inner surface is ineffective and diffusion within the catalyst is of no importance. With catalysts having intermediate values, however, diffusion to and from the catalyst interior is of major importance and thereby obscures the significance of empirically determined rate-equation constants that are based on some chemical step as controlling.

A separate study was made, therefore, on four sizes of the catalyst, including that size used for the mechanism study.

Experimental Determination of Effectiveness Factors

If tests are made on two different catalyst samples at the same temperature, pressure, and conversion, the ratio of the rates for the two runs becomes

$$\frac{r_2}{r_1} = \frac{E_2}{E_1} = \frac{(W/F)_1}{(W/F)_2}$$

where

1 and 2 refer to different catalyst samples.

Hence, in order to obtain the ratio of E_2/E_1, it is necessary to determine only the reciprocal space velocities which will produce the same conversion for the two catalysts at the same condition of temperature and pressure. To establish these values with assurance, several runs at different values of W/F must be made on each catalyst so that a portion of the x vs. W/F curve is established, thus facilitating interpolation. It follows that the most direct method for establishing the absolute value of the effectiveness factor for a given catalyst is to compare it with a sample having a value of unity. This requires a finely divided sample for which it can be assumed that both inner and outer surfaces are equally accessible or effective.

A second method employs the Hougen and Watson (*7*) modification of the Thiele (*10*) development. The ratio of Thiele moduli

$$\frac{M_2}{M_1} = \frac{D_{p_2}(F_{i_1})^{1/4}}{D_{p_1}(F_{i_2})^{1/4}}$$

where:

D_p = particle diameter
F_i = internal void fraction
M = Thiele modulus

can be determined from the appropriate physical measurements on the catalyst samples, and knowing the ratio of effectiveness factors for two catalysts, the modulus for each catalyst can be obtained from the plot presented by Hougen and Watson (*7*). The actual effectiveness factors can then be calculated from the expression relating the modulus to the effectiveness factor.

Both described methods were employed in this study.

APPARENT EFFECTIVENESS FACTORS

Apparent effectiveness factors for each of the catalyst samples were calculated by assuming a factor of unity for the fine catalyst (Catalyst No. 1) and dividing the value of W/F for Catalyst No. 1 by the W/F at the same conversion for the catalyst in question. These values, ranging from 0.13 to 0.23, are given in Table 2.

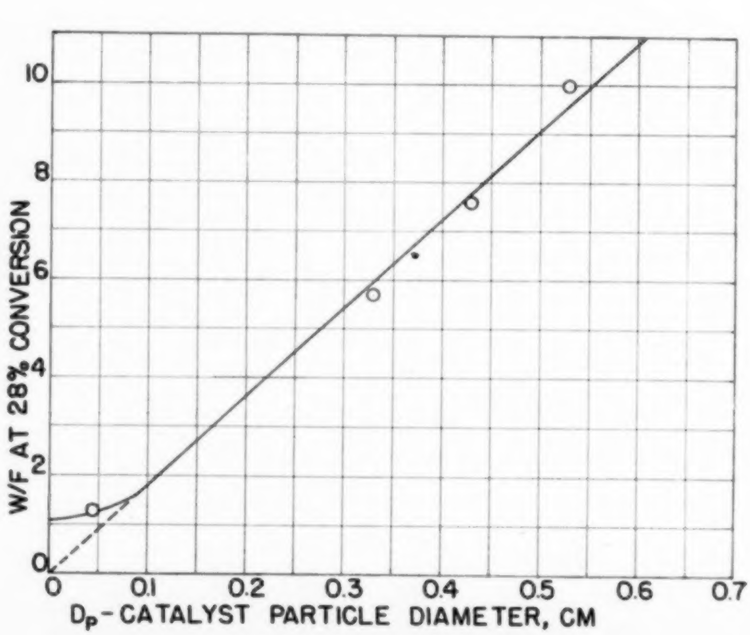


Fig. 7. Reciprocal space velocity vs. catalyst particle diameter.

W/F VS. EXTERNAL AREA

The low values of the apparent effectiveness factor strongly indicate that the inner surface of the particle is relatively ineffective.

The combined term EL in the rate equation which can be thought of as the total number of effective active sites per unit mass, is the only variable when comparing two catalyst samples at constant temperature pressure, and conversion. The integrated equation then becomes

$W/F = C/EL$, where C is a constant

If only the outside surface of the catalyst is effective, then EL becomes directly proportional to a_m, the outside surface area per unit mass.

$$\frac{W}{F} = \frac{C'}{a_m}$$

For a sphere

$$a_m = \frac{6}{D_p \rho_p}$$

where

ρ_p = particle density

But ρ_p was constant for all the samples tested

$\therefore W/F = C''D_p$

It can be shown, in like manner, that if the outer surface and a differential outside layer of the inner surface are effective, W/F is again essentially proportional to D_p. It may, therefore, be said that if the inner surface of the catalyst is ineffective, a plot of W/F at constant conversion vs. catalyst particle diameter should produce a straight line which will extrapolate to the origin.

Such a plot is presented in Figure 7, and a straight line is obtained. It is reasonable to assume that at some critical diameter both the inner and outer surfaces will become effective. Since the inner surface is approximately 3×10^5 larger than the outer surface, further division of the particles past this critical diameter will have no effect and the curve of W/F vs. D_p should reach a constant value of W/F at this point. This reasoning is the basis for the curving of the lower portion of the plot.

The most obvious criticism of these data is the lack of additional values in the lower diameter range. The trend, however, is so clearly defined that it can be said with reasonable assurance that the three sizes of commercial bead catalysts are effective only on the outer surface, or within an extremely thin outer shell. Holm (6) has reached a similar conclusion based on hydrogen transfer studies over silica-alumina catalyst at 340° C., using butane labeled with radioactive carbon. Wheeler in "Advances in Catalysis," Vol. 3 (3) has presented an interesting theoretical approach to reactions in pores of catalysts which suggests that for an active catalyst only the region near the pore mouth is useful since molecules react after a few collisions with the pore wall. Pore-size distribution measurements by Drake (2) have shown a high percentage of micropores in silica-alumina bead catalyst compared to pelleted catalyst, which may explain in part the lower effectiveness factors of the former.

CORRECTED EFFECTIVENESS FACTOR

The asymptotic value of W/F for 28% conversion can be obtained from Figure 7, and corrected values of the effectiveness factors calculated by dividing the asymptotic value by the value of W/F for the catalyst in question. Curves similar to Figure 7 were plotted at several other conversions, and effectiveness factors were calculated. No appreciable variation of effectiveness factor with conversion was noted.

EFFECTIVENESS FACTORS FROM THIELE'S MODULUS

Values of the effectiveness factors calculated using Hougen and Watson's modification of Thiele's concept are given in Table 2. Reasonable agreement with the values obtained by the direct method is evident, but the direct-method values are believed to be more reliable in this range of low-effectiveness factors.

EFFECTIVENESS FACTOR AND PARTICLE DIAMETER

In order to provide a correlation which may be more easily comprehended, a plot of reciprocal effectiveness factor vs. the particle diameter is presented in Figure 8. Since W/F is directly proportional to 1/E, a curve similar to Figure 7 is obtained.

A striking comparison of two catalysts is also given in Figure 8. The upper curve represents the data obtained in this study on cumene while the lower curve represents those of Pufahl (8) for the hydrogenation of iso-octane over pelleted nickel-supported catalyst of

Table 2.—Effectiveness Factors and W/F at 28% Conversion

Catalyst No.	D_p Diam. cm.	W/F	Effectiveness Factor Apparent	Actual	Thiele
0	0	1.1*	....	....	....
1	0.045	1.3	1.0	0.85	0.75
2	0.33	5.7	0.23	0.19	0.16
3	0.43	7.6	0.17	0.15	0.12
4	0.53	10.0	0.13	0.12	0.10

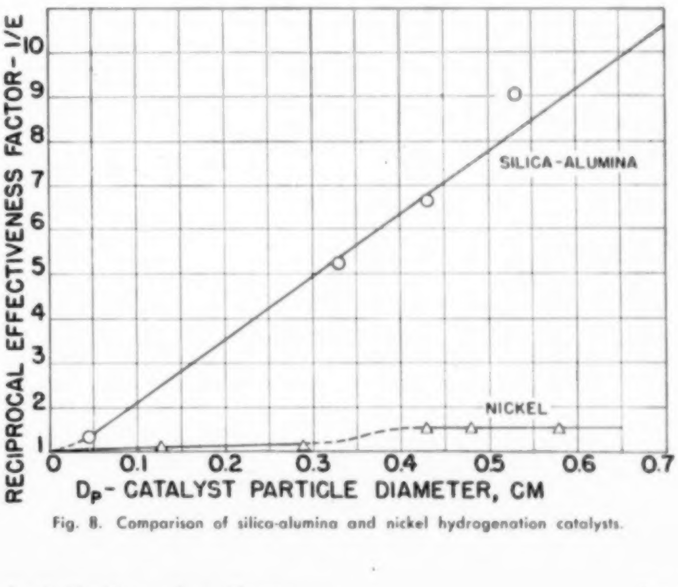


Fig. 8. Comparison of silica-alumina and nickel hydrogenation catalysts.

high effectiveness factor. It can be seen that $1/E$ decreases linearly with particle diameter for the T.C.C. bead catalyst but, for the nickel-supported catalyst, it is independent of particle diameter over a considerable range. A certain critical diameter is reached in each case at which the curve becomes asymtotic to maximum activity.

Since W/F at a given conversion is linear with D_p, a plot of W/FD_p vs. conversion should cause all the data for the various sizes of catalyst to fall on one curve. Figure 9 shows that such is the case within experimental limitations. Suen, Chien, and Chu *(9)* prepared a similar plot in their studies on the hydrogenation of ethyl alcohol with copper catalyst. Figure 9 is essentially a plot of conversion vs. total outside surface area per unit feed rate since $1/D_p$ is proportional to a_m.

Summary

It has been shown that a single-site surface reaction is the controlling mechanism for the catalytic cracking of cumene over silica-alumina catalyst. This mechanism is represented in Equations (9), (10), (11). Values of the constants in these equations are presented graphically as functions of temperature in Figure 5.

The silica-alumina bead catalyst was shown to be effective, for this reaction, only on the outside surface of the catalyst. Effectiveness factors for four sizes of catalyst are presented.

Acknowledgment

Financial aid from the Standard Oil Company of California, the Wisconsin Alumni Research Foundation, and the Wisconsin Engineering Experiment Station is gratefully acknowledged. The catalyst was furnished by the Socony-Vacuum Oil Co. Universal Oil Products performed a mass-spectrometer analysis, which was valuable in checking analytical methods. O. A. Hougen of the University of Wisconsin has been of assistance throughout this project.

Notations

A = cumene

a_m = catalyst outside surface area, sq. cm./g. of catalyst

b = intercept of π/r_o vs. π plot

C, C', C'' = constants

D_p = sphere particle diameter or diameter of a sphere of same outside surface area per unit volume as particle, cm.

E = effectiveness factor

F = feed rate, lb.-moles/hr.

F_i = internal void fraction

K = thermodynamic equilibrium constant

K_A = adsorption constant for cumene, single-site mechanism

K_A' = adsorption constant for cumene, dual-site mechanism

K_R = adsorption constant for benzene

K_S = adsorption constant for propylene

k = reaction velocity constant, single-site mechanism

k' = reaction velocity constant, dual-site mechanism

L = number of molal active sites/lb. of catalyst

l = an active catalyst site

M = Thiele modulus

m = slope of π/r_o vs. π plot

p_A = partial pressure of cumene, atm.

p_R = partial pressure of benzene, atm.

p_S = partial pressure of propylene, atm.

R = benzene

r = rate of reaction, lb. moles converted/(lb. of catalyst)(hr.)

r_o = initial reaction rate, rate at zero conversion

S = propylene

T = absolute temperature, °R.

W = weight of catalyst charge, lb.

x = conversion, moles feed converted/mole of feed fed

x^* = equilibrium conversion

Subscripts:

A = cumene

R = benzene

S = propylene

Greek Letters:

β = constant in integrated equation

$$= \frac{2}{ELkK_A\pi} + \frac{K_R}{ELkK_A}$$

γ = constant in integrated equation

$$= \frac{1}{ELkK_A\pi} + \frac{1}{ELk}$$

$\delta = \sqrt{1 + 1/K} = 1/x^*$

π = total pressure, atm.

ρ_p = particle density g./cc.

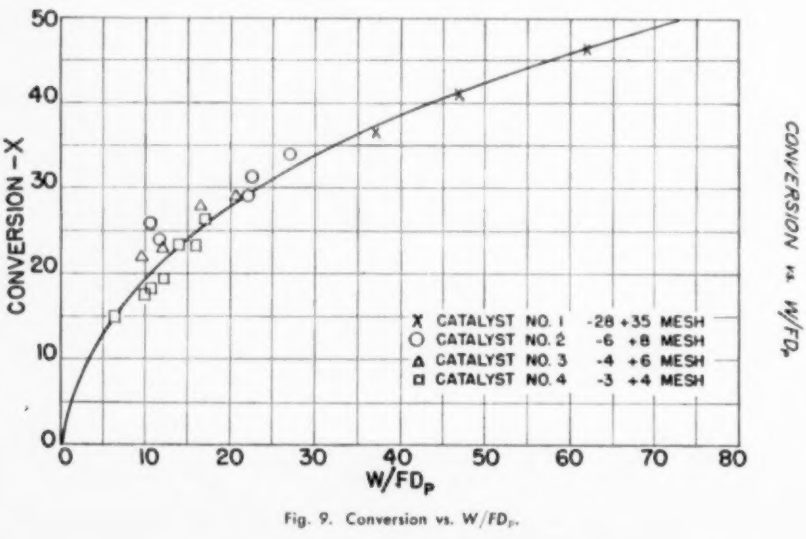


Fig. 9. Conversion vs. W/FD_p.

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Presented at A.I.Ch.E. Biloxi meeting.

Absorption of Hydrochloric Acid in Wetted-Wall Absorbers

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The present study was initiated primarily to obtain design data for the production of 36 to 40% hydrochloric acid from a chlorination plant by-product gas. The type of counter-current-flow packed towers described in a previous paper (*10*) are not suitable for producing acid stronger than 36%. Some work with wetted-wall hydrochloric acid absorbers had been previously reported in the literature (*3, 5, 6*), and it appeared that an absorber of this type should give a practical design. However, none of the available data covered the desired range of acid concentrations. Therefore, a single-tube test absorber was set up to obtain the necessary design data. With the experimental absorber once set up, the study was extended to cover the entire range of acid concentrations.

The test data were taken primarily to measure the over-all operation of a wetted-wall hydrochloric acid absorber and did not have sufficient details for theoretical calculations. Mass-transfer and heat-transfer coefficients were calculated, but, because of the approximate methods required for computations with the limited data, no attempts have been made at quantitative correlations.

Experimental Procedure

A schematic diagram of the experimental setup for the absorption tests is shown in Figure 1. Metered flows of hydrogen chloride gas and water were fed into the top of a water-jacketed absorption tube. The hydrochloric acid produced was drawn off from the bottom of a separator pot through a hydrometer jar, and the vent gases were sent through a small packed tower which scrubbed out the residual hydrogen chloride.

An annular type of water distributor is shown in Figure 1, but a number of runs were also made using an overflow weir distributor of the type described by Coull, et al. (3).

The rotameters were calibrated by collecting and measuring the volumes of water delivered during measured time intervals. The orifice meter used for the hydrogen chloride feed gas was calibrated from material balances based on water flows, acid concentrations, and the inlet gas composition.

The feed gas was obtained directly from a chlorination plant and was essentially constant in composition, the hydrogen chloride content varying between 83.3 and 83.9% for these tests. The inert gases were nitrogen, carbon dioxide, and chlorine.

The product acid strength was measured by means of a hydrometer in the seal leg as shown in Figure 1. The measured acid densities were converted to weight per cent hydrogen chloride using Ferguson's tables (*11*), since these tables are used as the standard for commercial acid. A later acid strength-density correlation by Akerlof and Teare (*1*) indicates acid concentrations higher than those from Ferguson's tables, but changes the amounts of hydrogen chloride absorbed by only 2 or 3%.

Temperature measurements were made from thermometers located in the gas feed line, the inlet water line, the product acid seal leg, and the cooling water lines.

The amount of hydrogen chloride in the vent gas was calculated from the water flow to and the hydrochloric acid strength from the vent gas scrubber. The vent gas composition was calculated by a material balance based on the inlet gas composition and the amounts of hydrogen chloride absorbed in the falling-film absorber and the vent scrubber. The vent scrubber acid strength was determined by titrating with standard NaOH, since it was usually too low for reliable density measurements.

The pressure drop across the absorption tube was measured with a manometer filled with carbon tetrachloride. (See Fig. 1.)

The cooling water rates were periodically measured by collection. Except for a few runs with the 1½-in. by 9-ft. Karbate tube, the rate was high enough to maintain velocities of greater than 5 ft./sec. in the cooling-water jacket.

Three different absorption tubes were used in the present study, as follows: (a) a Karbate tube 1½-in. I.D. and 2-in. O.D. by 9 ft. long, (b) a tantalum tube 1-in. I.D. and 1.06-in. O.D. by 6 ft. long, and (c) a stainless steel tube 0.88-in. I.D. and 1-in. O.D. by 11 ft. 10 in. long. A total of 124 runs was made in the three absorption tubes producing hydrochloric acid over the range from 15 to 41%. Inlet gas velocities ranged from 30 to 110 ft./sec. in the smaller tubes and from 7 to 35 ft./sec. in the Karbate tube. It should be noted that the upper range of gas flows was limited by the hydrogen chloride gas supply and not by any of the observed operating characteristics of the absorber.

Representative experimental data are presented in Table 1, showing the results obtained with the 1-in. × 6-ft. tantalum tube using a glass gas inlet tube to form a 0.010-in. annular water distributor. A complete tabulation of the experimental data is available from the American Documentation Institute.

Experimental Results

The usual experimental procedure was to make a series of runs at a constant gas flow rate, varying the liquid flow and recording the changes in hydrochloric acid concentrations and temperatures. Data from two such series of runs in the tantalum tube are shown in Figures 2 and 3, in which acid concentrations and temperatures are plotted vs. water flow for a constant gas flow rate.

These two series of runs covered the transition from streamline to turbulent liquid flow and were the first in which the effect of this change on the over-all absorption of hydrogen chloride was observed. It can be seen from these two plots that at equivalent water rates, i.e., at 0.245 gal./min. for 2.45 lb. mole/hr. gas flow and at 0.330 gal./min. for 3.30 lb. mole/hr., the higher gas flow resulted in a stronger acid which left the absorber at a lower temperature.

Acid concentrations and temperatures

For complete tabular data, order document 4047 from A.D.I. Auxiliary Publications Photoduplication Service, Library of Congress, Washington 25, D. C., remitting $1.25 for microfilm or $1.25 for photoprints readable without optical aid.

Copies of tables are available at research department, The Dow Chemical Co., Pittsburg, Calif.

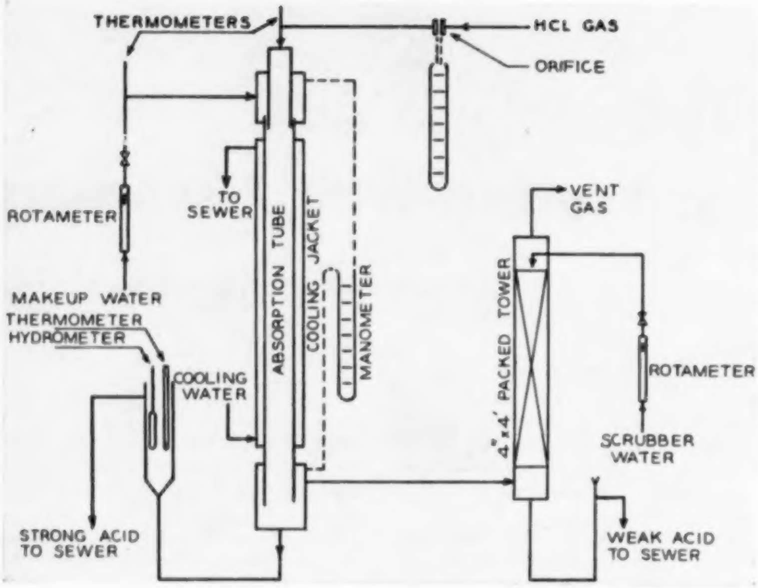
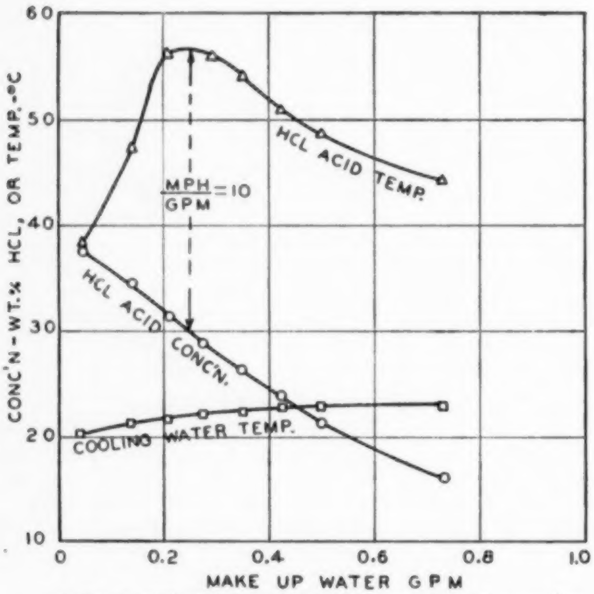


Fig. 1. Wetted-wall HCL absorber layout.



▲ Fig. 2. HCl acid temperatures and concentrations for gas flow of 2.45 lb. mole/hr.

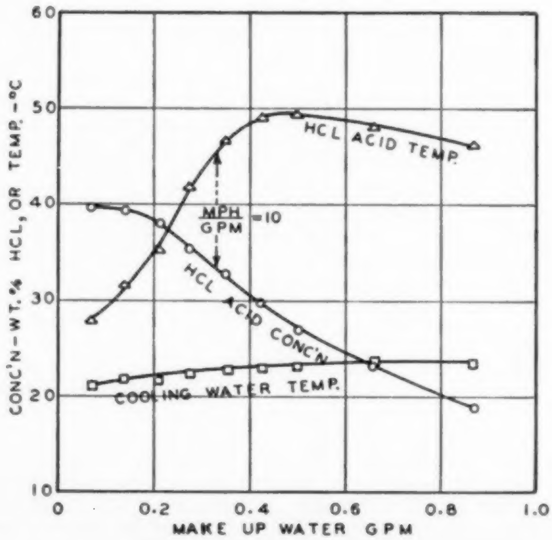
Fig. 3. HCl acid temperatures and concentrations for gas flow ▶ of 3.30 lb. mole/hr.

for a constant water-gas flow ratio were picked from similar plots for other gas velocities and are plotted in Figure 4. This plot is a good example of the net over-all effect of changes in gas velocity on the absorption of hydrogen chloride in a concurrent flow, wetted-wall, water-cooled absorber. Similar curves were obtained for other water-gas flow ratios.

Qualitatively, a decrease in hydrochloric acid concentration with increasing flow rate had been expected, since previous correlations (*9, 13*) had indicated that both mass-transfer and heat-transfer coefficients were proportional to less than the first power of the mass velocity. The relationship shown in Figure 4, however, indicates that the acid concentration is independent of gas velocity except in the range from 2.5 to 3 lb. mole/hr. (50 to 60 ft./sec.). This was the first indication that in this high velocity range mass-transfer coefficients in wetted-wall absorbers are not proportional to the 0.8 power of the mass velocity as reported in previous correlations.

The temperature curve shows the expected increase in temperature with increasing gas flow, but it also shows a pronounced break at a gas flow of about 3 lb. mole/hr. (50 to 60 ft./sec.). The breaks observed in both the temperature and the concentration curves indicated that there was a radical change in the flow patterns in the tube in this velocity range.

To confirm this a check of the flow characteristic of a similar two-phase flow system was made with air and water in a 1-in. glass tube. At air velocities below 50 ft./sec., the water flowed smoothly down the tube walls in streamline flow. Between 50 and 60 ft./sec. air velocity there was a change to extreme turbulence with slugs of



The production of hydrochloric acid in a concurrent flow, wetted-wall, water-cooled absorber was studied for acid concentrations from 15 to 41% and for inlet gas velocities from 7 to 110 ft./sec. Mass-transfer coefficients appeared to be proportional to the 1.8 power of the gas velocity. Heat-transfer coefficients and two-phase pressure drops showed qualitative agreement with previous correlations.

spray apparently extending completely across the tube and moving at approximately the same velocity as the gas. This change in the visually observed flow pattern occurred at the same gas velocity as the previously observed change in absorption characteristics, and, it is believed to be one of the primary causes for the abrupt changes observed in acid temperature and concentrations.

The fact that, as observed in Figure 4, the acid concentration for a given water-gas ratio was independent of gas flow rate, led to the development of a useful plot which is shown as Figure 5. Here the per cent of hydrogen chloride in the vent was plotted against the acid concentration, and it was found that almost all the test data for a given tube could be represented by two lines, one for low gas velocities and one for high velocities. The complete range of gas velocities was covered in the tests in the 1-in. by 6-ft. tube and two curves were obtained. All the test data from the $1\frac{1}{2}$-in. by 9-ft. tube were at low gas velocities and the water was in the streamline liquid flow region. The data can therefore be represented by a single line. Conversely, all the test data from the $\frac{7}{8}$-in. by 11-ft. tube were at high velocities and also can be represented by a single line.

Data obtained by Coull, et al. (3) in a $\frac{7}{8}$-in. by 9-ft. tube have been included in Figure 5 for comparison and show generally good agreement.

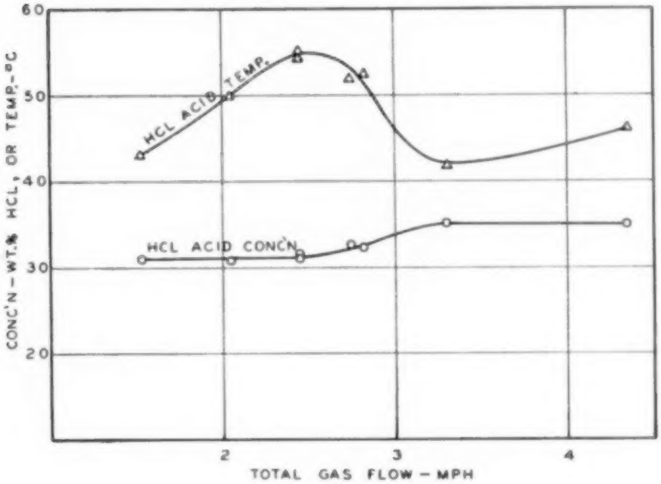


Fig. 4. HCl acid temperatures and concentrations for constant water-gas flow ratio of 12 lb.-mole/(hr.)/gal./min.

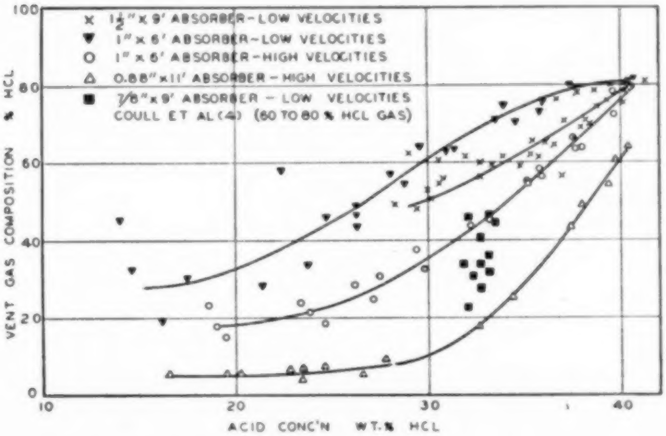


Fig. 5. Vent gas composition vs. HCl acid concentration.

Mass-Transfer Coefficients

It was assumed that the gas phase would be controlling and mass-transfer coefficients were calculated from the log mean average of the difference between the partial pressure of the HCl in the gas and the equilibrium vapor pressure of HCl over the liquid at the inlet and the outlet of the absorption tube. It is realized that the log mean average is not rigorously applicable in the present case, but it appears to be the most practical method of calculating mass-transfer coefficients in the absence of any knowledge on true temperature and concentrations within the absorption tube.

The hydrogen chloride vapor pressures over the exit acid were determined from the measured concentrations and temperatures by use of the table in Perry (12). None of the data from tests producing acid stronger than 36% was used for these calculations, since for strong acid the vapor pressures determined in this way were consistently greater than the measured hydrogen chloride content of the vent gas.

The amount of hydrogen chloride absorbed was calculated from the measured flow of water and the hydrochloric acid concentration.

The area was taken as the inside area of the absorption tube. The unexpectedly large effect of velocity on the mass-transfer coefficient may be due partially to this assumption, since the air-water tests in the glass tube indicated a large increase in the interfacial area for conditions of turbulent liquid flow.

The calculated mass-transfer coefficients are plotted vs. the inlet mass velocity of the gas in Figure 6 and vs. the average velocity in Figure 7. The plot of mass transfer vs. inlet velocity shows slightly less scatter of the data than that for the average velocity, but there is no clear-cut difference. The inlet velocity apparently establishes the flow pattern which carries on through the tube and thus has a disproportionately large effect on the over-all mass transfer which is not accounted for in the average velocity.

Both plots show what appears to be a smooth continuous increase of the mass-transfer coefficient with increasing gas velocity and there is no indication of any discontinuities at the transition from streamline to turbulent flow. This confirms the assumption of gas-phase controlling absorption, since the change in flow characteristics of the liquid should then have no great effect on the gas-phase transfer coefficient.

The break in the acid concentration curve observed in Figure 4 seemingly contradicts this, but it can be readily

explained by the marked drop in acid temperature which occurred over the same velocity range. The lowering in temperature reduced the equilibrium vapor pressure of hydrogen chloride over the acid, and the increased partial pressure driving force resulted in the production of stronger acid.

It can be seen, however, that in the range covered by the present tests, changes in gas velocity have a much greater effect on mass transfer than those reported in previous correlations. A straight line drawn through the present data would have a slope of about 1.8 instead of 0.8 as previously reported. It should be noted that most of the present data were obtained at higher velocities than those used for previously reported tests.

Heat Transfer

Similarly to the mass-transfer calculations, detailed calculations of heat-transfer coefficients are not justified for the data obtained in the present study. The step-by-step analysis described by Coull, et al. (*3*) requires a balance of heat transfer and mass transfer, and it was clearly demonstrated that the correlations ordinarily used for these factors are not applicable in the ranges covered in the present tests. However, approximate calculations to indicate the order of magnitude of the heat-transfer coefficients should be instructive.

Approximate heat-transfer coefficients were calculated from the HCl absorption data as follows:

1. The amount of heat transferred was calculated from an enthalpy balance based on the amount of HCl absorbed and the inlet and outlet temperatures using Van Nuys' (15) enthalpy data.
2. It was assumed that the temperature of the inlet water rose almost immediately to 108° C., the boiling point of the constant boiling mixture. This temperature, along with the measured temperatures of the exit acid and of the cooling water, was used to calculate an average-temperature difference for the absorption tube. In order that this assumption have reasonable validity, it was restricted to use with acid containing more than 25% HCl.
3. Over-all heat-transfer coefficients were then calculated, based on the total inside area of the absorption tube.
4. Liquid-film coefficients were calculated based on a water side coefficient of 2,000 B.t.u./(hr.)(sq.ft.)(° F.), a fouling factor of 0.002, and effective coefficients for the tube walls of 1,500 B.t.u./(hr.)(sq.ft.)(° F.) for the stainless tube, 13,000 for the tantalum tube, and 4,000 for the Karbate tube.

The heat-transfer coefficients calculated in this manner are plotted against liquid rate in gallons per minute per foot of periphery (Fig. 8). The effect of gas rate is also shown in this plot.

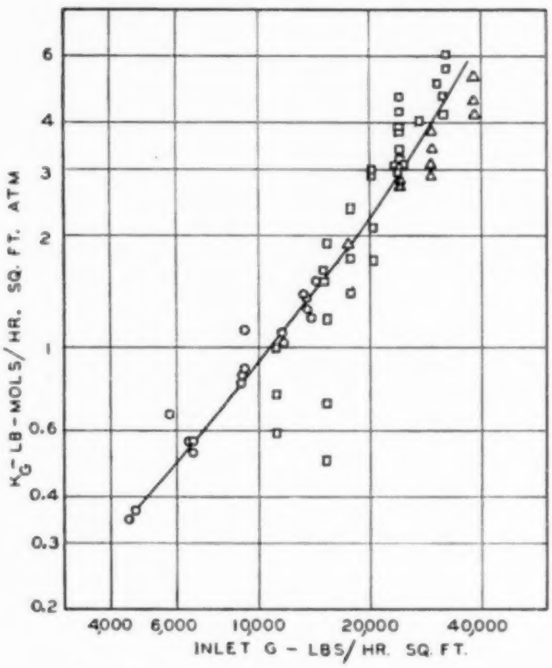


Fig. 6. Mass-transfer coefficients vs. inlet gas velocity.
□ 1 in. × 6 ft. absorber tube
○ 1.5 in. × 9 ft. absorber tube
△ 0.88 in. × 11 ft. absorber tube

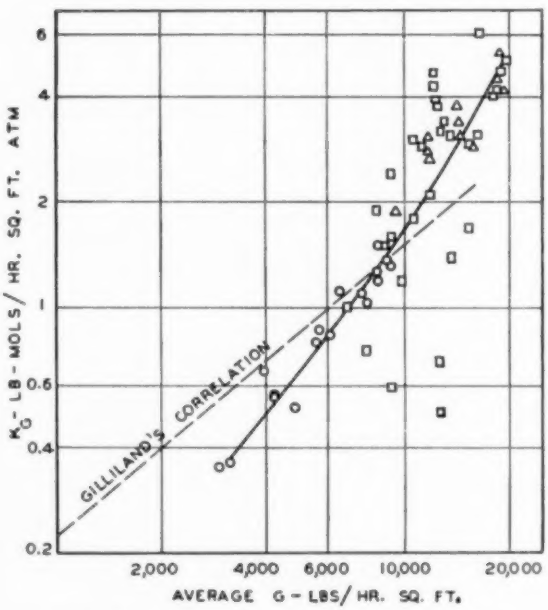


Fig. 7. Mass-transfer coefficients vs. average gas velocity.
□ 1 in. × 6 ft. absorber tube
○ 1.5 in. × 9 ft. absorber tube
△ 0.88 in. × 11 ft. absorber tube

Lines of constant inlet velocity have been drawn in and show reasonably good agreement with the slope of 1/3 predicted by the correlation for falling films in McAdams (*9*).

Values from Figure 8 have been cross-plotted in Figure 9 to show the effect of changes in gas velocity on the heat-transfer coefficients at a constant liquid rate. The reversal in the temperature curve observed in Figure 4 appears here as a definite change in the effect

of mass velocity on heat transfer in the range from 20,000 to 30,000 lb./hr. (sq.ft.).

Previous work on the effect of vapor velocity on heat-transfer coefficients in two-phase flow has been concerned primarily with condensers. Data of Tepe and Mueller (*14*) have been plotted in Figure 10 and show a change in slope which appears to corroborate the change in flow characteristics observed in the present report at G=20,000 lb./(hr.)(sq.ft.). However, it must be noted that two different materials—methanol and benzene—were used in these condensation tests and the differences in physical properties may have had an effect.

Data presented by Carpenter (*2*) could also be interpreted as showing a change in slope at G = 20,000 lb./(hr.)(sq.ft.), but again the effect is not clear cut.

Johnson and Abou-Sabe (*7*) have reported heat-transfer data for two-phase flow of air-water mixtures in a horizontal tube. They did not observe any trends comparable to those reported in the present paper, but this lack of agreement can be attributed to the difference in flow patterns for two-phase flow in horizontal and vertical tubes as reported by Gazley (*4*).

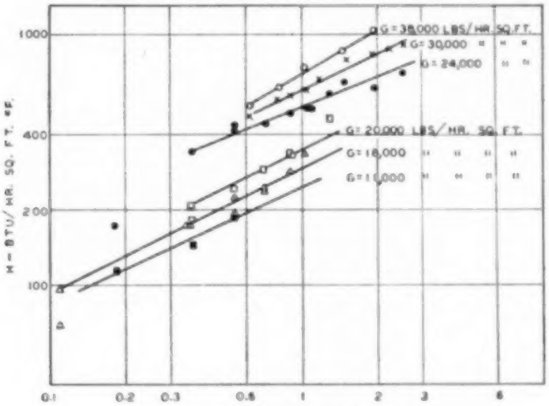


Fig. 8. Heat-transfer coefficients vs. liquid rate.

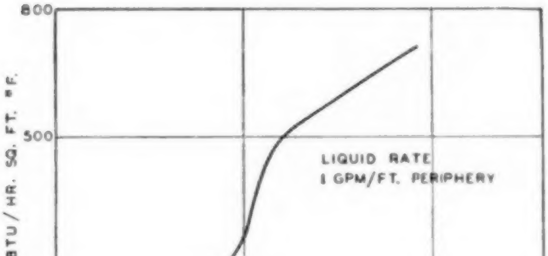


Fig. 9. Heat-transfer coefficients vs. gas rate.

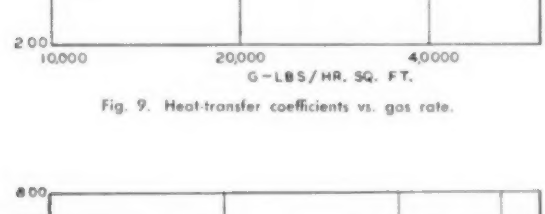


Fig. 10. Effect of mass velocity on condensing coefficients inside tube.

Pressure Drop

The pressure drop across the HCl absorption tube was measured for most of the test runs made with the tantalum and stainless steel tubes. Several different methods of correlation were attempted for these data with the most consistent results obtained by the use of a "roughness factor" applied to the friction factor for gas flow. The observed pressure drop was between two and three times that calculated for the average gas flow through a smooth-walled pipe with no clear-cut effect of changes in liquid rate. Representative data for tests with the 1-in. × 6-ft. tantalum tube are shown in Table 2.

The correlation for pressure drop in condenser tubes reported by Gazley, et al. (*4*) gave calculated values in relatively good agreement with the experimental values from the present study. Because of the spread of the data, the change in pressure drop predicted for changes in liquid rate could not be confirmed, however. The same factors which prevent exact calculations for heat transfer and mass transfer also prevent exact calculations of pressure drop. The amounts of gas and liquid change appreciably in going through the absorption tube, and a section-by-section calculation would be required for exact calculations. But, as mentioned in previous sections, the flow pattern through the tube is not known and an over-all average value should give the best readily available answer.

The correlation developed by Lockhart and Martinelli (*8*) gave calculated pressure drops consistently higher than the measured values. As explained by Gazley, this appears to come from the fact that the Lockhart and Martinelli correlation was based on two-phase flow in horizontal tubes. Gazley showed that pressure drops for two-phase flow in horizontal tubes were appreciably greater than for concurrent downward flow in vertical tubes.

Water Distribution

Experimentation with several types of tube inlet gas and water distributors showed that large amounts of fog are

Table 1.—Typical Observed Data

ABSORPTION OF HCL FROM 83% HCL GAS IN 1-IN. × 6-FT. TANTALUM TUBE

Run No.	Feed Gas Flow lb.mole/hr.	Feed Gas Temp. °C.	Makeup Water Flow gal./min.	Makeup Water Temp. °C.	Cooling Water Temp. In, °C.	Cooling Water Temp. Out, °C.	Product Acid Conc'n. wt. % HCL	Product Acid Temp. °C.	Exit Gas Flow lb.mole/hr.	Exit Gas Conc'n. mole % HCL
97	2.07	25.1	.66	20.3	19.6	22.6	14.0	47.3	.64	45.3
98	2.07	25.5	.315	20.6	19.8	22.6	22.4	61.1	.84	58.4
99	2.07	26.0	.07	21.1	20.0	21.5	33.9	47.3	1.40	75.0
100	2.76	26.7	.50	21.0	20.0	24.6	25.9	52.4	.73	34.8
101	2.76	27.3	.35	21.2	20.0	24.5	28.4	53.1	.85	44.8
102	2.76	28.0	.14	21.2	20.1	22.6	36.2	42.8	1.53	69.3
105	3.30	27.6	.87	21.0	20.0	25.3	18.6	51.8	0.73	23.5
104	3.30	27.7	.425	21.0	20.0	25.5	29.4	52.0	.90	37.8
103	3.30	27.8	.21	21.3	20.0	24.0	37.6	36.7	1.69	66.8
106	4.38	28.4	.87	21.0	20.0	27.0	23.9	56.0	.95	21.3
107	4.34	28.3	.46	21.0	20.0	26.4	32.2	51.6	1.33	44.0
108	4.22	29.5	.35	21.2	20.0	25.5	35.4	45.2	1.60	55.0

Table 2.—Typical Pressure-Drop Data

ABSORPTION OF 83% HCL IN 1-IN. × 6-FT. TUBE

Run No.	G_{avg} lb./(hr.)(sq.ft.)	L gal./min./ft.	$\Delta P/\Delta L$(obs.) in. CCl_4/ft.	$\Delta P/\Delta L$(calc.) in. CCl_4/ft.	ΔP Ratio $\left(\frac{obs.}{calc.}\right)$
55	16,600	0.17	0.25	0.092	2.7
57	13,200	0.80	0.17	0.062	2.7
59	11,700	1.34	0.125	0.050	2.5
61	11,100	1.91	0.125	0.045	2.8
63	20,000	0.17	0.35	0.13	2.7
65	15,700	0.80	0.25	0.085	2.9
67	14,000	1.34	0.21	0.070	3.0
69	21,800	0.27	0.39	0.15	2.6
71	17,700	0.80	0.33	0.105	3.2
73	15,600	1.63	0.25	0.083	3.0
75	14,700	1.91	0.25	0.076	3.2
88	19,100	1.20	0.33	0.122	2.7
89	19,800	0.92	0.35	0.128	2.8
90	19,400	3.33	0.50	0.125	4.0
91	20,800	1.76	0.46	0.142	3.2
82	14,600	3.33	0.29	0.073	4.0
83	14,900	1.91	0.23	0.077	3.0
84	16,800	1.05	0.25	0.097	2.6

formed in the wetted-wall HCl absorber whenever the water leaves the tube wall at the inlet. The combination of uncooled water or weak acid and high partial pressures of HCl seems to be the most effective for fog formation. Slugging of the liquid at the exit of the absorption tube produced little or no observable fog.

The most successful type of water distributor consisted simply of a gas inlet tube extending down into the cooled section of the absorption tube, so that a small annulus was formed to allow water entry (Fig. 1). With this arrangement the water is directed down the walls of the absorption tube as a film and the gas enters in parallel flow. Tests with air and water in a 1-in. diam. glass tube indicated that an annulus width of 0.020 in. is the maximum size that will give smooth water flow with negligible spraying at the inlet. The effect of poor initial water distribution was tested by experiments with the gas inlet tube off center and touching the wall of the absorption tube and also with one half of the annulus completely plugged. These showed that at high gas velocities the tube was completely wetted, but at low gas velocities the poor initial water distribution would sometimes persist all the way through the tube.

The gas velocity at which poor initial water distribution was rectified was about 55 ft./sec., the same as the minimum velocity required to accelerate the water film to turbulent flow.

Several types of water distributors utilizing the top edge of the absorption tube as a weir gave excessive fog formation at high gas velocities. Apparently, the *vena contracta* of the entering gas stream sucked water off the tube walls into the center of the tube where it reacted with the strong hydrogen chloride gas to form fog. Aside from fog formation, there were no measurable differences in the performance of the absorption tubes with different water distributors, which indicates that the amount of water spray required for the fog formation is relatively small.

Notation

G_{inlet} = gas flow rate at tube inlet—lb./(hr.)(sq.ft.)

G_{avg} = average gas flow rate—lb./(hr.)(sq.ft.)

h = apparent heat-transfer coefficient for acid film—B.t.u./(hr.)(sq.ft.)(° F.)

L = water flow rate—gal./min./ft. of periphery

K_G = apparent mass-transfer coefficient—lb.-mole/(hr.)(atm.)(sq.ft.)

U = apparent over-all heat-transfer coefficient—B.t.u./(hr.)(sq.ft.)(° F.)

MPH = gas flow rate—lb. mole/hr.

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Experiments with Many Factors

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Simple Experiment

For a long time the approved method of investigating a process with a number of variables was to vary them one at a time. If consideration is given to a process with six variables, and the testing of these only at two levels each, then the two possible levels of each factor can be represented by the symbols 0 and 1. Thus, the symbol 000000 denotes that set of conditions with all six factors at their lower level, and the symbol 010100 represents that set with the second and fourth factors at their upper levels and the remaining factors at their lower levels. If one were to investigate the effects of these six factors according to the traditional principles, then observations would be made with the following sets of conditions:

$$000000,\ 100000,\ 010000,\ 001000,\ 000100,\ 000010,\ 000001 \qquad (1)$$

Here the first symbol represents the so-called "control" or standard, and the succeeding six represent trials with each variable altered in turn, the remaining five variables being held constant at their lower, or standard, levels. On the basis of a comparison of each experimental trial with the control, a decision on the use of that factor at its upper level or its lower level would be made. The over-all decision would be the sum of the individual decisions.

Factorial Experiment

Sometimes the foregoing procedure would not prove satisfactory. A study of data in Table 1 is suggested. Figures therein represent mean cross-sectional areas for cakes of two types baked from batters with two pH's. If a simple experiment had been executed, there would be only those observations marked with an asterisk. The effect of changing from low to high acidity, keeping the type of cake at chocolate, gives a larger cake area; and the effect of changing the kind of cake, keeping the acidity at its low value, also gives a larger cake area. Therefore, both these factors at their upper levels should be used, but actually this condition is less optimal than the high acidity, chocolate-cake combination. An effect of this type, where the separate effects of the two factors are not additive, is known to the statistician as an interaction. Another way of looking at it is to observe that the effect of one factor varies according to the level of the other factor. Interactions involving two factors are known as first-order interactions. If a first-order interaction between two factors A, and B, varies according to the level of a third factor C, then this is called a second-order interaction and denoted symbolically as $A \times B \times C$. The relationship between three factors involved is symmetrical, so that the interaction between A and C, varying according to the level of B, and the interaction between B and C, varying according to the level of A, are identical with the $A \times B \times C$ interaction.

In order to detect and measure the presence of interactions in a multifactor system, one must make, not the simple one-variable-at-a-time experiment, but a factorial experiment which consists of all combinations of all factors. In addition to being able to detect interactions, it has the advantage, where interactions are absent, of greater efficiency than the simple experiment. This efficiency arises through the ability to take averages over all observations for estimating the effects of each of the factors. This is in contrast to the simple experiment where each observation, other than the control, serves to provide information only on the factor that was varied for that particular trial (*7*).

Algebraic Representation of Effects

To consider how the factorial experiment uses all its observations to estimate the average effect of a factor, the following symbolism is introduced: The small letters a, b, c, etc., denote that the factor in question is at its upper level, and the absence of a letter implies that the factor is at its lower level. Thus, in a six-factor experiment the treatment combination $a\ c\ e$ has factors A, C, and E at their lower levels and factors B, D, and F at their lower levels. The symbol (1) denotes the treatment combination with all factors at their lower levels. In the previous notation $a\ c\ e$ would represent 101010. A slight ambiguity in notation can be tolerated: symbols of the type $a\ c\ e$ will be used to represent both the particular combination of levels and also the numerical result, be it yield or purity or some other property, obtained from that experimental condition.

For simplicity, a factorial experiment with three factors is considered. There will be $2^3 = 8$ treatment combinations, namely, (1), a, b, ab, c, ac, bc, abc. There will be four estimates of the effect of A, as in Table 2. The average effect of these four estimates is defined as the main effect of A,

$$A = \tfrac{1}{4}[(a-1)+(ab-b)+(ac-c)+(abc-bc)]$$
$$= \tfrac{1}{4}(a-1)(b+1)(c+1) \qquad (2)$$

There will be two possible first-order interactions involving A, namely, AB and AC. To consider AB, it is defined as one-half the mean difference between the effect of A with B at its upper level (averaged over both levels of c),

$$\tfrac{1}{2}[(abc-bc)+(ab-b)]$$

and of A with B at its lower level (averaged over both levels of C),

$$\tfrac{1}{2}[(ac-c)+(a-1)].$$

This difference, divided by two, is

$$AB = \tfrac{1}{2}[\tfrac{1}{2}\{(abc-bc)+(ab-b)\} - \tfrac{1}{2}\{(ac-c)+(a-1)\}]$$
$$= \tfrac{1}{4}(a-1)(b-1)(c+1) \qquad (3)$$

One could have considered AB as one-half the mean difference between B with A at its upper level (averaged over both levels of C) and B with A at its lower level (averaged over both levels of C). This would have led to the same result (*3*).

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A second-order interaction involving all three factors is conceivable. One way to obtain it is to consider one-half the mean difference between the AB interaction for the upper level of c,

$$\tfrac{1}{2}[(abc - bc) - (ac - c)]$$

and the same for the lower level of c,

$$\tfrac{1}{2}[(ab - b) - (a - 1)].$$

Half the difference between these two is

$$\begin{aligned} ABC &= \tfrac{1}{2}[\tfrac{1}{2}\{(abc - bc) - (ac - c)\} \\ &\quad - \tfrac{1}{2}\{(ab - b) - (a - 1)\}] \\ &= \tfrac{1}{4}(a - 1)(b - 1)(c - 1). \end{aligned} \tag{4}$$

The alternative viewpoints will lead to the same result.

The general method of writing down the arrangement of treatment combinations to give an estimate of any specified effect will be obvious from an inspection of (2), (3), and (4). All letters occur on the right-hand side of these equations in the form $(a \pm 1)(b \pm 1)(c \pm 1)$. If a letter occurs on the left-hand side, i.e., if α, β, or $\gamma = 1$, then the corresponding

of numbers of runs $(64/63) \times 0.281 = 0.296$. The simple experiment thus has an efficiency in measuring main effects relative to the factorial of less than 30%. The larger the experiment, the greater the relative efficiency of the factorial arrangement.

Fractional Replication of Factorial Experiments

The main disadvantage of the factorial experiment is that the number of runs required becomes rather large for a large number of factors. Even when all factors are at two levels, a six-factor experiment requires sixty-four runs, an eight-factor experiment 256 runs. Such large numbers of runs are often greater than is either practical or necessary from the point of view of estimating the effects with a specified accuracy. The need exists, therefore, for designs which will retain the efficiency aspect of the factorial experiment and the capability of detecting the presence of interactions. The solution to this problem lies in replicating only a certain fraction of the whole factorial experiment. The tech-

Table 1

	Chocolate (C_0)	White (C_1)	$C_1 - C_0$
Low acidity (A_0)	36.87*	42.44*	5.56
High acidity (A_1)	51.56*	48.44	−3.12
$A_1 - A_0$	14.69	6.00	

sign in the bracket on the right-hand side is minus, otherwise plus. In the general case where there are n factors, the divisor is 2^{n-1}, and one has

$$A^{\alpha}B^{\beta}C^{\gamma}\ldots = \frac{1}{2^{n-1}}[a - (-1)^{\alpha+1}]$$
$$[b - (-1)^{\beta+1}][c - (-1)^{\gamma+1}]\ldots \tag{5}$$

It will be noted that the expressions (2), (3), and (4) for the various effects each employs all results of the experiment. Thus, in the case of a six-factor experiment, if the interactions are not significant, the main effect of A is estimated as the difference between two averages each of thirty-two observations. If the simple experiment represented by expression (1) had been replicated nine times, it would have required sixty-three runs, almost exactly the same as the factorial experiment which required sixty-four, but its estimates of the factors are the differences between two averages each of nine observations. The ratio of the variance of the two experiments will then be $9/32 = 0.281$, or if adjusted by the ratio

nique is due to Finney (*6*) and the rationale is along the following lines. For fuller accounts *see* (*2, 5, 9*).

Next under consideration is a four-factor experiment in which only half the treatment combinations were used. The sets are those with a plus sign in the expression for $ABCD$. These will be

$$(1), ab, ac, bc, ad, bd, cd, abcd \tag{6}$$

An estimate of the main effect of A, for example, will be the difference between the average of those with A at its upper level and the average of those with A at its lower level:

$$\begin{aligned} A &= \tfrac{1}{4}[ab + ac + ad + abcd - (1) \\ &\quad - bc - bd - cd] \end{aligned} \tag{7}$$

Examining the arrangement of results for estimating BCD, which would in a full replicate be

$$\begin{aligned} &(a + 1)(b - 1)(c - 1)(d - 1) \\ &= \tfrac{1}{8}[ab + ac + ad - bc - bd - cd \\ &\quad - a + b + c + d - abc - abd - acd \\ &\quad + bcd + abcd - (1)] \end{aligned} \tag{8}$$

However, in this half-replicated experiment there are only the eight treatment combinations given in (6). Using these, our estimate of BCD is

Table 2

Level of B	Level of C	Estimate of a
Lower	Lower	$a - (1)$
Upper	Lower	$ab - b$
Lower	Upper	$ac - c$
Upper	Upper	$abc - bc$

$$\begin{aligned} BCD &= \tfrac{1}{4}[ab + ac + ad + abcd - (1) \\ &\quad - bc - bd - cd] \end{aligned} \tag{9}$$

but this is identical with our estimate of A in (7).

Similarly if one expands $AB = \tfrac{1}{8}(a - 1)(b - 1)(c + 1)(d + 1)$ and $CD = \tfrac{1}{8}(a + 1)(b + 1)(c - 1)(d - 1)$ and selects the eight treatment combinations in (6), one arrives at the following:

$$\begin{aligned} AB &= \tfrac{1}{4}[abcd + ab - ac - ad - bc \\ &\quad - bd + cd + (1)] = CD \end{aligned} \tag{10}$$

If the $2^4 - 1 = 15$ effects in this way are written out, it will be found that they fall into seven pairs, making fourteen, with the fifteenth being that used for selecting the 2^3 treatment combinations, here $ABCD$. The pairings are

$$\begin{array}{ll} A = BCD & AB = CD \\ B = ACD & AC = BD \\ C = ABD & AD = BC \\ D = ABC & \end{array} \tag{11}$$

It can be seen that the rule for finding the alias of any effect is to multiply it by $ABCD$, using the rule that $A^2 = B^2 = C^2 = D^2 = 1$. For example,

$$A = A \times ABCD = A^2BCD = BCD$$

From the practical point of view the half-replicate experiment just outlined is not satisfactory as it leads to appreciable ambiguity. The main effects with second-order interactions as aliases are probably all right, as if, for example, one found $A = BCD$ to be appreciable it would be much more probable to be A than BCD, as it is an empirical observation that main effects are more often appreciable than high-order interactions. The first-order interactions are, however, hopelessly confused.

As the number of factors in the experiment is increased, the risk of ambiguity decreases. When one gets to the six-factor experiment, which as a half-replicate requires thirty-two treat-

Table 3

	a_0	a_1
b_0	1	2
b_1	0	3

Table 4

		B_0				B_1			
		S_0		S_1		S_0		S_1	
		A_0	A_1	A_0	A_1	A_0	A_1	A_0	A_1
C_0	T_0	43	58*	39*	54	49*	67	50	59*
	T_1	38*	53	38	55*	44	58*	36*	51
	T_2	34	50*	34*	46	42*	56	31	45*
	T_3	30*	47	25	41*	33	49*	24*	36
C_1	T_0	45*	51	40	47*	49	57*	45*	53
	T_1	41	46*	42*	46	45*	54	47	54*
	T_2	41*	45	42	47*	45	50*	44*	49
	T_3	37	44*	37*	44	41*	43	38	45*

* Results available.

Table 5

Source of Variance		Sums of Squares: Half-Replicate	Sums of Squares: Full Replicate
Chocolate vs. white ....(C)		16.531	23.767
Baking powder ....(B)		75.031	185.641
Shortening ....(S)		75.031	159.391
pH ....(A)		935.281	1,711.891
Storage time ....(T):	L	507.656	1,212.903
	Q	9.031	13.141
	C	3.906	8.128
C × B		7.031	5.641
C × S		34.031	83.266
C × A		166.531	301.891
B × S		26.281	37.516
B × A		2.531	0.391
S × A		3.781	1.891
C × T:	L	79.806	196.878
	Q	0.031	3.516
	C	0.006	0.153
B × T:	L	12.656	71.253
	Q	1.531	0.141
	C	0.156	2.278
S × T:	L	0.306	1.378
	Q	16.531	15.016
	C	10.506	5.778
A × T:	L	0.506	0.903
	Q	1.531	1.266
	C	28.056	3.003
Remainder		20.439*	184.093†
Total		2,034.719	4,231.109
Residual mean square		3.4065*	4.8446†

* With 6 degrees of freedom.
† With 38 degrees of freedom.

ment combinations, it is an experiment adequate for many purposes. The aliases are of the type

$A = BCDEF$ (six such)
$AB = CDEF$ (fifteen such)
$ABC = DEF$ (ten such).

The second-order interactions would be used as estimates of error, and the danger of ambiguity in the main effects and first-order interactions is small. An example of this design applied to plant-scale penicillin fermentation has been given by Brownlee (*3*).

The great disadvantage of testing a factor at two levels only is that the existence or position of a maximum or minimum cannot be estimated. There are some factorial replicates which include one or more factors at four levels, the remainder being at two levels. The smallest experiment of this type which can be considered reasonably secure is the $4^1 \times 2^4$, i.e., one factor at four levels and four factors at two levels. This design is derived from the 2^6 by allocating two of the two-level factors to represent the four-level factor. The two pseudo-factors are arranged as in Table 3. Thus $(1) = 1$, $a = 2$, $b = 0$, $ab = 3$, where 0, 1, 2, and 3 are levels of the four-level factor.

Half-replicate Example

As an example of this design the results of an experiment on the baking of a cake will be considered (*10*). The dependent variable under study was the average cross-sectional area in square inches. The cakes were of two kinds, chocolate and white (denoted by C_0 and C_1). They were made with one of two baking powders (sulfate-phosphate and tartrate, B_0 and B_1). The original experiment had three types of shortening, but only two are included here, butter and vegetable shortening, denoted by S_0 and S_1. The pH's of the mixtures were adjusted to either of two values and these are denoted by A_0 and A_1. There were four storage times. The experiment is thus $4^1 \times 2^4$, and the author fully replicated it. However, it can be analyzed as though it had been a half-replicate, in which case only the results marked with an asterisk in Table 4 would be available.

In a half-replicate one way of determining which is the appropriate set of treatment combinations is to use the method by which these designs were examined, namely, to expand the highest-order interaction and use only those treatment combinations with a plus sign. Here would be expanded:

$$(a-1)(b-1)(c-1)(d-1)$$
$$(e-1)(f-1). \qquad (12)$$

The combinations of a and b would then have to be converted into levels of the four-level factor by using Table 3. Allocating T to a and b, B to c, S to d, A to e, and C to f, then the entry $T_0B_0S_0C_0T_0$ in Table 3 is a, which has a negative sign in the expansion of (12) and so is not included in the half-replicate. However, $T_3B_1S_1A_1C_1$ is $abcdef$, and this has a plus sign in the expansion of (12) and so is included. Although this method of finding the treatment combinations is the simplest, there is an alternative which is more expeditious (*2, 6, 9*).

The interpretation of the results of a complex experiment clearly requires some special techniques for just by looking at the data it is difficult to determine what there is to see. The tool, the statistician uses, is the analysis of variance. Broadly speaking, this analyzes the variance, defined as the sum of the squares of the deviations of the observations from the mean, divided by the degrees of freedom, into its constituent components attributable to the various effects. Those components which are significantly larger than the error, are looked at; the remainder, in general, are forgotten. For the analysis of variance *see* (*8, 13*). The analysis of variance of data of Table 4 is in Table 5, both for the half-replicate and for the full replicate.

In the present instance the four-level factor represents a quantitative variable, being storage time. If the assumption is made that the intervals between successive levels are equal, then it becomes easy to test the fit of a polynomial equation of the form

$$y = a + bx + cx^2 + dx^3.$$

Table 6

Effect	Half-Replicate	Full Replicate
$B_1 - B_0$	3.06 ± 1.8	3.41 ± 1.11
$S_1 - S_0$	3.06 ± 1.8	3.16 ± 1.11

$A \times C$	C_0	C_1	$C_1 - C_0$		C_0	C_1	$C_1 - C_0$
A_0	36.50	42.50	6.0	A_0	36.87	42.44	5.56
A_1	51.87	48.75	−3.12	A_1	51.56	48.44	−3.12
$A_1 - A_0$	15.37	6.25		$A_1 - A_0$	14.69	6.00	

Confidence limits:

for difference between two means 2.54   1.58

for difference between two such differences 3.60   2.23

$C \times T$	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
C_0	51.25	46.75	42.75	36.00	52.37	46.62	42.25	35.62
C_1	48.25	46.75	45.50	41.75	48.37	46.87	45.37	41.12
$C_1 - C_0$	−2.75	0.00	2.75	5.75	−4.00	0.25	3.12	5.50

Confidence limits:

for difference between two means 3.60   2.23

for difference between two differences 5.09   3.15

$S \times C$	C_0	C_1	$C_1 - C_0$	C_0	C_1	$C_1 - C_0$
S_0	46.75	46.12	−0.63	46.94	45.87	−1.06
S_1	41.62	45.12	3.50	41.50	45.00	3.50
$S_1 - S_0$	−5.12	−1.00		−5.54	−0.87	

$B \times T$	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
B_0	47.25	45.25	43.00	38.00	47.12	44.87	42.37	38.12
B_1	52.50	48.25	45.25	39.75	53.62	48.62	45.25	38.62
$B_1 - B_0$	5.25	3.00	2.25	1.75	6.50	3.75	2.87	0.5

Table 7

			A_0			A_1			A_2		
			B_0	B_1	B_2	B_0	B_1	B_2	B_0	B_1	B_2
C_0	D_0	E_0	63	...	...	...	...	60	...	73	...
		E_1	...	...	117	...	98	...	96	...	...
		E_2	...	130	...	110	...	...	...	...	122
	D_1	E_0	...	...	100	...	85	...	89	...	...
		E_1	...	119	...	115	...	...	...	...	141
		E_2	138	...	...	...	...	140	...	142	...
	D_2	E_0	...	92	...	106	...	...	...	...	94
		E_1	117	...	...	...	...	119	...	129	...
		E_2	...	...	154	...	154	...	158	...	...
C_1	D_0	E_0	...	...	32	...	35	...	32	...	...
		E_1	...	64	...	81	...	...	...	...	38
		E_2	100	...	...	...	...	112	...	98	...
	D_1	E_0	...	54	...	80	...	...	...	...	61
		E_1	95	...	...	...	...	95	...	95	...
		E_2	...	...	124	...	123	...	130	...	...
	D_2	E_0	60	...	...	...	...	61	...	75	...
		E_1	...	...	106	...	107	...	111	...	...
		E_2	...	130	...	147	...	...	...	...	137
C_2	D_0	E_0	...	15	...	22	...	...	...	...	0
		E_1	47	...	...	...	...	30	...	32	...
		E_2	...	...	72	...	185	...	85	...	...
	D_1	E_0	40	...	...	...	...	10	...	25	...
		E_1	...	...	69	...	69	...	60	...	...
		E_2	...	120	...	112	...	...	...	...	106
	D_2	E_0	...	...	50	...	70	...	43	...	...
		E_1	...	84	...	104	...	...	...	...	91
		E_2	123	...	...	...	...	132	...	130	...

In the analysis of variance in Table 5, the three degrees of freedom for T, both in the main effect and in its interactions, have been partitioned in components attributable to the linear, quadratic, and cubic terms of the polynomial. If the bulk of the sum of squares for the main effect lies in the linear term, with the quadratic and cubic terms not significantly larger than the remainder, then it can be said that straight lines represent the data sufficiently well. If a linear component of an interaction, say $C \times T_L$, is significant, this means that the slopes of the lines of response against T are different for the two levels of C. This use of orthogonal polynomials has been described *(1, 2, 9)*.

The interpretation of an analysis of variance such as Table 5, presents difficulties arising out of the multiplicity of tests being made at the selected significance level. Considering the half-replicate, using the ordinary variance ratio test, the interactions between C and A, C and the linear component of T, and C and S would be judged significant. If one takes account of the number of tests being made, however, Nair *(12)*, the last mentioned, $C \times S$, would not be judged significant. The main effects of those factors involved in interactions are not of interest: those not involved in interactions are B and S and each of these is significant. If the whole replicate is considered, the interaction between C and S, which was somewhat dubious on the half-replicate, is significant. The same is true for the interaction between B and the linear component of T.

Having decided from the analysis of variance what effects to look at, the author then constructs the relevant tables of means (Table 6). All confidence limits quoted are for 95% confidence. Limits for the full replicate are naturally somewhat smaller as this uses twice the number of observations as the full replicate.

It will be noted that the half-replicate gives similar conclusions to the full replicate. It could well have been that the half-replicate was sufficiently accurate for some purposes, in which case the amount of work required would have been cut in half.

Fractional Replication with Factors at Three Levels

Finney *(6)** has shown how the ideas just expressed can be extended to experiments with all factors at three levels. Here the three levels of the factor A are represented by (1), a, and a^2, and similarly for the other factors. Each factor

* The table on page 300 of his paper is in error and has been corrected in Ann. Eugenics, **15**, 276 (1950).

Table 8

Source of Variance		Sums of Squares
A	L	8.963
	Q	616.395
B	L	153.352
	Q	323.710
C	L	23,856.019
	Q	301.488
D	L	16,189.352
	Q	358.525
E	L	65,940.167
	Q	42.525
AB	LL	84.028
	QL	640.454
	LQ	0.231
	QQ	541.855
AC	LL	106.778
	QL	1,309.037
	LQ	31.148
	QQ	33.383
AD	LL	373.778
	QL	166.259
	LQ	0.593
	QQ	670.234
AE	LL	26.694
	QL	270.750
	LQ	26.009
	QQ	179.262

Source of Variance		Sums of Squares
BC	LL	476.694
	QL	131.120
	LQ	621.120
	QQ	375.929
BD	LL	21.778
	QL	25.037
	LQ	416.148
	QQ	382.420
BE	LL	110.250
	QL	8.898
	LQ	290.083
	QQ	363.114
CD	LL	200.694
	QL	528.898
	LQ	76.676
	QQ	322.003
CE	LL	2,567.111
	QL	625.926
	LQ	27.000
	QQ	11.864
DE	LL	128.444
	QL	237.037
	LQ	120.333
	QQ	116.160

Error	Sum of squares	6,147.265
	Degrees of freedom	30
	Mean square	204.909
Total sum of squares		126,582.988

Table 9

	E_0	E_1	E_2	$E_2 - E_0$
C_0	84.7	116.8	138.7	54.0
C_1	54.4	88.0	122.3	67.9
C_2	30.6	65.1	118.3	87.7
$C_2 - C_0$	−54.1	−51.7	−20.4	

will have two degrees of freedom which can be represented by symbols of the type A, A^2. Two elements are defined $a^{\alpha}b^{\beta}c^{\gamma}$ . . . and $A^{\alpha'}B^{\beta'}C^{\gamma'}$ . . . to be orthogonal if

$$\alpha\alpha' + \beta\beta' + \gamma\gamma' + \ldots = 0 \bmod 3$$

where 0 mod 3 means that on division of the sum of the product of the coefficients by 3 a remainder of zero is obtained.

To construct a one-third replicate of the 3^5 experiment, i.e., an experiment with five factors all at three levels, the alias subgroup can be selected.

$$I = ABCDE = A^2B^2C^2D^2E^2.$$

The treatment subgroup will consist of all elements orthogonal to this, namely, (1), ab^2, a^2b, ac^2, . . . abc, $a^2b^2c^2$, . . . abc^2d^2, . . . $ab^2c^2d^2e^2$ . . . .

There will be eighty-one elements which satisfy the orthogonality condition. The effect symbols will be confused in triplets of the type

$$\begin{aligned}
A &= A^2BCDE = B^2C^2D^2E^2\\
A^2 &= BCDE = AB^2C^2D^2E^2\\
AB &= A^2B^2CDE = C^2D^2E^2\\
A^2B &= B^2CDE = AC^2D^2E^2\\
AB^2 &= A^2CDE = BC^2D^2E^2\\
A^2B^2 &= CDE = ABC^2D^2E^2
\end{aligned}$$

Two of the four degrees of freedom of the interaction between A and B are confused with two of the eight degrees of freedom of C, D, and E, but ordinarily this will not give trouble.

Table 10

d_0	d_1	d_2
72.0	94.0	106.8

Data from such an experiment is given in Table 7. It seems that only one third of the usual number of runs has been made. The experiment was on a laboratory scale on a fermentation system and the five factors represent concentration of five of the ingredients. The dependent variable in the table is a function of yield. The analysis of variance is in Table 8. The only effects of importance are the interaction of factors C and E, for which the averages are given in Table 9, and the main effect of D for which the averages are given in Table 10.

It is apparent that this experiment was satisfactory. A factorial experiment was shown to be necessary as otherwise the interaction between C and E would have been completely overlooked. On the other hand, the one-third replicate was sufficiently accurate to delineate the effects with adequate precision, so the objective was obtained with only eighty-one fermentations instead of 243.

Other Possibilities in Fractional Replication

Space here does not permit an exploration of all the possibilities of fractional replication. The following, however, might be mentioned:

a. It is possible to break up all the experiments into smaller blocks so that heterogeneity in the experimental background will be eliminated from the estimation of effects. This device is known as confounding (2, 5, 6, 9).

b. In the 2^n system, for moderately large n, satisfactory designs exist which replicate smaller fractions than one half, in particular one quarter, or one eighth, etc. (2, 6, 9).

For example, with eight factors, requiring 256 runs for the full replicate, a certain set of sixty-four can be chosen to give a relatively unambiguous experiment. This is known as a quarter-replicate.

c. In the 2^n system, designs exist with some factors at four levels and others at two levels in addition to that illustrated in this paper (4).

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Presented at A.I.Ch.E. Forty-fifth annual meeting, Cleveland, Ohio.

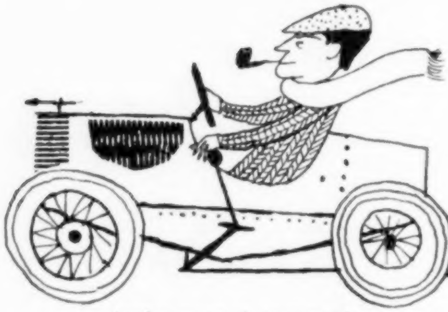
The writer of this article, Edward John Cullen, as the holder of the Esso Petroleum Co.'s studentship is working for his Ph.D. at Cambridge University, where he previously took a six-month engineering course under the R.A.F. Short Course Program. After serving in the R.A.F. he returned to Cambridge, receiving his M.A. in chemical engineering in June 1952. Subsequently he entered the University of Texas as the recipient of a joint fellowship offered by the Pan-American Clipper Club and the University of Texas, to study for an M.S. in chemical engineering. He graduated with this degree in August, 1953.

EDITOR'S NOTE

Every year foreign students and professors come to the United States, either on scholarships, fellowships sponsored by international organizations or industry, or on university exchange arrangements. What influence, one wonders, does the American scene have upon the visitors? How much do they imbibe of the atmosphere here? And more especially what is their reaction to the educational methods on this side of the Atlantic?

In the accompanying article Edward J. Cullen, a student at Cambridge University, tells of the year (1952-53) he spent at the University of Texas as a graduate student in chemical engineering. In a subsequent issue an American abroad will have a hearing.

Life at an American University



Another aspect of university life.

Few things in this world, it seems to me, are more interesting or more baffling than the process of orientation at an American university. One might suppose that after the first few weeks of becoming familiar with crew cuts and hot rods, of afternoon cokes and cookies instead of tea and cakes, and becoming enlightened on "dating" one's social adjustment might be considered complete. Indeed, superficially it is, but now looking back I realize that throughout my year I constantly found new aspects in the university life. The process of orientation is a never-ending one.

Attendance at Lectures Compulsory

The differences in the systems of education go much deeper. The first inkling of the changes I might expect came during my first lecture, when the professor informed the class that assignments would have to be handed in on time or the grade would suffer. Having been educated under a system which exerted no compulsion on the student to complete assignments, my first reaction was one of rebellion and I was tempted to ask whether I was in a graduate class or back in high school. But more was to follow. One morning, after an especially late night I was tempted to miss a lecture for the pleasure of a few more hours' sleep. However, my fellow students soon put me right on that score. To a British student cutting a lecture is just that and nothing more, for there are legendary stories of undergraduates at Cambridge who obtained their degrees although they had not attended a single lecture. But to an American student such a course would surely lead to disaster.

Perhaps the greatest shock I received was that the students appeared to be working extremely hard. The Hollywood conception of university life in the States, which I had carefully built up in my mind, was soon shattered and before long I was forced to the conclusion that students must work much harder than their British contemporaries.

The system is such that the American student has to work intensively and continually. There are reports to be written, quizzes to be faced, assignments to be handed in, and final examinations to be passed. He must have the facts at his fingertips and the ability to use both accurately and quickly the methods he has been taught.

Casual Approach to Study

In contrast I might record that one notable feature about Cambridge is the incidental and apparently lackadaisical approach to study. The British student is under no immediate compulsion to work and consequently he is able to devote some time to exploring topics for which he has a particular yen. In that way his studies are more a matter of enjoyment and interest. There is, of course, this disadvantage—some students have too much leisure and then have to "cram" hurriedly for the yearly examinations. The vacations, which are much longer at Cambridge, are utilized as a respite in which reading and previously neglected work are brought up to date. This is in strong contrast to the American student, who uses his vacations to restore his bank account. The student who works his way through college in Britain is a rarity.

My reaction to this apparently overwhelming rush of work was one of amazement, and, lurking at the back of my mind, I had the suspicion that I was going somewhere fast without being too sure where I was going. Nothing is simpler for the Briton, full of the idea of the superiority of his own system, than to sit back and fire criticism at the American, but before long I began to realize that the pattern of education was relevant to the American scene. I might add that in a short time my pride made me break away from my previous ideas and in the matter of work I became indistinguishable from the other students in my class.

Separating Sheep from Goats

Another important difference is that the American universities are open to everyone who has an average or even a below-average-grade record. There are, of course, wide variations in the entrance requirements to the many universities scattered over the country, but it is fair to say that anyone who has the slightest chance of obtaining a degree is allowed the opportunity to attempt such a course. In Britain the selection procedure is much more rigorous and a proportionally smaller number of students enter the universities each

year. The process of sorting the sheep from the goats at a much earlier stage is possible because the students start specializing in their last two years of high school and their ultimate success in their chosen field can be judged more accurately. Hence, though the British universities take only the cream of the talent, the American ones take the "milk" as well. With the wider range of intelligence groups present at American universities, there is, of necessity, a bigger emphasis laid on career-type courses than here in Britain.

Then again, another factor which has to be taken into account in comparing the two systems of education is that the average American student entering the university is at a scholastic standing roughly corresponding to that of a British student two years before he enters the university. Thus the system has to be geared to make up for this difference and the American college student is harder pressed than his British colleague.

Ph.D.—A Research Degree

With regard to chemical engineering in particular, the system in use at Cambridge is somewhat unusual. The course, which is fixed and is the same for all students, is regarded as a graduate one and anyone wishing to pursue it must first spend two years on engineering or science. Thereafter the students spend two years "doing" chemical engineering, and the course includes most of the subjects which are available in a typical American graduate school. Once a student has completed this course, he is at once allowed to study for his Ph.D., which is solely a research degree, involving no course requirements whatsoever. I heard criticized the "research" Ph.D. for allowing the student to lose his general background, but that seemed to me to be unjust since most Ph.D. students should be mature enough to avoid such a possibility. Research study does have the advantage, however, of developing a cooperative attitude amongst the graduate students, since the competition of the course work is no longer present.

British Student and Relaxation

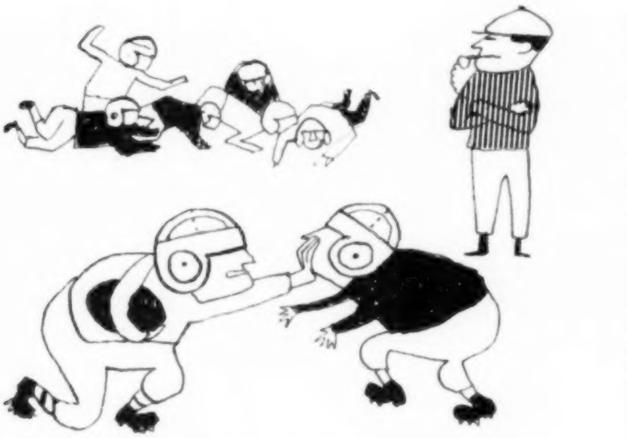
Outside the academic field, I found the American student disposed of his leisure with the same zeal as he carried out his studies. He was much less prone to relax in his room with a book, or spend it arguing noisily over cups of coffee than the British student. He seemed to feel that he must be doing something and this evidenced itself in the many clubs, the rallies, the numerous parties, and the interest in campus politics. The most striking feature, not seen in British universities at all, is the numerous beauty-queen contests. Whether this facet was peculiar to the University of Texas, which, I was told, had the most beautiful women in North America, including their neighbors the U.S.A., I was never quite able to find out. But it does point out the much bigger influence that women play in university life in the U.S.A. Many more women attend the universities, though in many cases their quests may not be entirely academic.

My own extracurricular activities were as numerous as my studies would allow, and sometimes more. I enjoyed the pageantry and vigor of the football games, the barracking of the baseball games, the picnics and parties, and the evenings spent on serious discussions. On a number of occasions I gave talks on topics on which I had first-hand knowledge and often these led to arguments in which I found myself defending ideas which previously had been almost axioms in my life. Such is the benefit of going to another country where one is thrown into close contact with people of an entirely different background. In a reciprocal fashion, I hope that many of my American friends had a similar feeling. At least, I was able to convince one old lady at a meeting that the solution of Britain's economic problem did not lie in the sale of the Crown Jewels, so my year was not entirely wasted.

Intrinsic Worth of Student Exchange

Despite attempts by my fellow Texans —a term I use correctly since I was made an honorary citizen of that State —to convince me that once I had seen Texas I might as well go home, because subsequently everything else would be an anticlimax, I did manage to travel quite extensively in the United States. In company with an Australian student, I bought an old car, which was used for traveling on vacations and for a seven-week period after leaving the University and before returning to Britain. We traveled over most of the country, living a nomadic life and camping all the way. Everywhere we found hospitality and friendliness, but this was somewhat overpowering when demonstrated by the black bears in National Parks.

But the motor trip all over the States was more than just a vacation; it was the climax of one of the most interesting and happiest years of my life, one I can look back on with recollections of the generosity and the kindness of the American people. If understanding each other is a way to friendship between our two countries, then each yearly exchange of students must bind that friendship still tighter.



I say, old fellow—this isn't Rugby!

The meaning of a liberal education.

IMPERVIOUS CARBON AND GRAPHITE

C. E. FORD National Carbon Company, Cleveland, Ohio

DESCRIPTION: Impervious carbon and graphite are carbon and graphite impregnated with chemically resistant synthetic resins. The unimpregnated material is slightly permeable, but, when resin is polymerized in its pores, it is rendered impervious to fluids under pressure and its strength is increased. Impregnation does not change the thermal conductivity of the base materials. With the proper resin impregnant, the materials may be utilized under practically all chemical conditions to which the base material is resistant.

APPLICATION AND REMARKS: Impervious carbon and graphite are fabricated into a variety of products for the chemical processing, metallurgical, petrochemical, pharmaceutical, etc., industries. The high thermal conductivity of impervious graphite (8 to 10 times that of stainless steel), combined with its corrosion resistance to acids, alkalies and organic compounds at boiling temperatures, and its immunity to thermal shock, make it ideal for many applications in corrosive environments. Karbate † No. 21 is a standard phenolic impregnated impervious graphite. Karbate No. 22 is a modified phenolic impregnated impervious graphite.

TEMPERATURE LIMITATIONS: Products are not affected by thermal shock, may be operated under any conditions which keep the temperature in the body of the material below 338° F. (170° C.).

RESIN BASE CEMENTS: Synthetic resin base cements which possess strength and chemical resistance characteristics similar to those of impervious carbon and graphite materials are recommended to produce weldlike permanent joints in the fabrication of the products. National No. 14 cement is an acid catalyzed, phenol formaldehyde resin base cement recommended for service in most acids, salt solutions and organic compound. With threaded joints will give serviceable life. National No. 15 cement is a modified phenolic resin base cement recommended for service in most alkalies and the chlorinated hydrocarbons for which National No. 14 cement is not suitable.

MACHINABILITY: Graphite can be sawed, turned, drilled, threaded, tapped or otherwise machined at high speeds, with the same machinery and in the same manner as hardwoods. Carbon can be machined in a manner similar to that used for cast iron.

IMPERVIOUS CARBON AND GRAPHITE PRODUCTS ‡

TYPICAL PROPERTIES

	Carbon	Graphite
Apparent density, g./cc.	1.77	1.87
Tensile strength, lb./sq.in.	1800	2500
Compressive strength, lb./sq.in.	10,000	9,000
Flexural strength, lb./sq.in.	4400	4700
Elastic modulus, $\times 10^6$, lb./sq.in.	2.8	2.2
Specific resistance, ohm. in.	0.0016	0.00034
Thermal conductivity, B.t.u./(hr.)(sq.ft.)(°F./ft.)	3	86
Mean coefficient of thermal expansion (70° F.-212° F.) $\times 10^{-7}$/°F.	29	24

Chemical Reagent	Concentration	Temperatures	Recommendation: Grade	Recommendation: Cement
ACIDS				
Acetic acid	All	Boiling	22	14
Acetic anhydride	100%	Boiling	22	14
Arsenic acid	All	Boiling	22	14
Boric acid	All	Boiling	22	14
Carbonic acid	All	Boiling	22	14
Chromium trioxide, aq. soln.	0-10%	200° F.	22	14
Citric acid	All	Boiling	22	14
Formic acid	Al	Boiling	22	14
Hydrobromic acid	All	Boiling	22	14
Hydrochloric acid	All	Boiling	22	14
Hydrofluoric acid	0-48%	Boiling	22	14
Hydrofluoric acid	48-60%	185° F.	22	14
Hydrofluoric acid	Over 60%	Not recommended		
Hydrogen sulphide-water	All	Boiling	22	14
Lactic acid	All	Boiling	22	14
Monochloracetic acid	100%	212° F.	22	14
Nitric acid	0-10%	185° F.	22	(†)
Nitric acid	10-20%	140° F.	22	(†)
Nitric acid	Over 20%	Not recommended		
Oleic acid	100%	Boiling	22	14
Oxalic acid	All	Boiling	22	14
Phosphoric acid	0-85%	Boiling	22	14
Stearic acid	100%	Boiling	22	14
Sulfuric acid	0-75%	Boiling	22	14
Sulfuric acid	75-96%	338° F.	22	(†)
Sulfuric acid	Over 96%	Not recommended		
Sulfurous acid	All	Room	22	14
Tartaric acid	All	Boiling	22	14
ALKALIES				
Ammonium hydroxide	All	Boiling	22	15
Monethanolamine	All	Boiling	22	15
Sodium hydroxide	0-67%	Boiling	21	15
Sodium hydroxide	67-80%	275° F.	21	15
Tetramine C	All	Boiling	21	15
SALT SOLUTIONS				
Aluminum chloride	All	Boiling	22	14
Ammonium thiocyanate	0-63%	Boiling	22	14
Arsenic trichloride	100%	230° F.	22	Not recommended
Calcium chlorate	0-10%	140° F.	22	14
Calcium hypochlorite	All	90° F.	22	14
Cupric chloride	All	Boiling	22	14
Ferric chloride	All	Boiling	22	14
Ferrous chloride	All	Boiling	22	14
Ferrous sulfate	All	Boiling	22	14
Manganous sulfate	All	Boiling	22	14
Nickel chloride	All	Boiling	22	14
Nickel sulfate	All	Boiling	22	14
Phosphorus trichloride	100%	Boiling	22	14
Sodium chloride	All	Boiling	22	14
Sodium chlorite	0-4%	Room	22	14
Sodium hypochlorite	0-25%	Boiling	21	—
Stannic chloride	All	Boiling	22	14
Zinc ammonium chloride	All	Boiling	22	14
Zinc chloride	All	Boiling	22	14
Zinc sulfate	All	Boiling	22	14
HALOGENS, AIR, WATER				
Air	—	338° F.	22	14
Bromine	100%	Not recommended		
Bromine water	All	Room	22	14
Chlorine-dry	100%	Room	22	14
Chlorine water	All	Room	22	14
Iodine	100%	Not recommended		
Fluorine	100%	Not recommended		
Steam	—	338° F.	22	14
Water	—	Boiling	22	14
ORGANIC COMPOUNDS				
Acetone	0-100%	Boiling	22	14
Amyl alcohol	100%	Boiling	22	14
Aniline	100%	338° F.	22	14
Aniline hydrochloride	0-60%	Boiling	22	14
Benzene	100%	Boiling	22	14
Benzene hexachloride	100%	212° F	22	14
Butyl alcohol	100%	Boiling	22	14
Butyl Cellosolve	0-100%	Boiling	22	14
Carbon tetrachloride	100%	Boiling	22	14
Cellosolve	0-100%	Boiling	22	14
Chlorethylbenzene	100%	257° F.	21	14
Chloroform	100%	Boiling	22	14
Deoxidine	—	140° F.	22	14
Dowtherm	100%	339° F.	22	14
Dioxan	0-100%	Boiling	22	14
Ethyl alcohol	0-100%	Boiling	22	14
Ethylene chlorohydrin	0-8%	122° F.	22	14
Ethylene dibromide	100%	200° F.	22	14
Ethylene dichloride	100%	Boiling	22	14
Ethyl mercaptan-water	Saturated	Boiling	22	14
Freon 11 and 12	100%	Room	22	14
Gasoline	100%	Boiling	22	14
Glycerine	0-100%	338° F.	22	14
Isopropyl acetate	100%	Boiling	22	14
Isopropyl alcohol	0-100%	Boiling	22	14
Isopropyl ether	100%	Boiling	22	14
Kerosene	100%	Boiling	22	14
Mannitol	All	Boiling	22	14
Methyl isobutyl ketone	100%	Boiling	22	14
Methyl alcohol	0-100%	Boiling	22	14
Monochlor benzene	100%	Boiling	22	14
Octyl alcohol	100%	Boiling	22	14
Paradichlorbenzene	100%	Boiling	22	15
Paraldehyde	100%	Boiling	22	14
Tetrachlorethane, sym.	100%	Boiling	22	14
Trichlorethylene	100%	Boiling	22	14
MIXTURES				
Ammonium persulfate plus sulfuric acid	25% 20%	Room	22	14
Calcium chloride plus calcium chlorate	30% 10%	140° F.	22	14
Chloronated ethyl alcohols	All	Boiling	22	15
Chrome plating solns.	All	Not recommended		
Hydrochloric acid sat. with chlorine	Over 20% All	Boiling	22	14
Nickel plating solns. (chloride)	All	Boiling	22	14
Nickel plating solns. (sufate)	All	Boiling	22	14
Nitric acid pus hydrofluoric acid	15% 5%	140° F.	22	(†)
Oakite Acid Materials—O.C. 32, O.C. 33, O.C. 36, O.C. 84A, O.C. 84M, CRYS. 87, O.C. 88	All	Boiling	22	14
Parkerizing solution	All	Boiling	22	14
Rayon spin bath	All	Boiling	22	14
Sodium hypochlorite plus sodium hydroxide	0.25% ??	Boiling	21	—
Sulfuric acid plus nitric acid	96% .03%	Not recommended		

† Karbate is a registered trade-mark of Union Carbide and Carbon Corporation.

‡ Tables show grade of Karbate impervious graphite and the type of National resin base cement recommended for commercial use with the more common corrosive chemicals. Concentrations and temperatures are based on field and laboratory experience, but satisfactory use of these materials is not limited to the chemical reagents or conditions shown.

No. 27

Gateway to the West

Article prepared by Richard G. Kerlin, Mallinckrodt Chemical Works, St. Louis, Mo.

Left to right, seated: David S. Weddell, Monsanto Chemical Co., chairman, Publicity Comm.; Donald F. Chamberlain, Washington University, Plant Trips Comm.; Kenneth R. Hancock, C. K. Williams & Co., chairman, Hotel & Meeting Rooms Comm.; standing: Robert E. Lenz, Monsanto Chemical Co., chairman, Housing Comm.; Charles B. Roen, Monsanto Chemical Co., chairman, Finance Comm.

When more than two thousand chemical engineers and guests converge upon St. Louis for the A.I.Ch.E. meeting, Dec. 13-16, 1953, they will find themselves in the heart of the foremost city in the Mississippi Valley with a wide spectrum of attractions. Evidence of the colorful past remains in the timeworn cobblestones on the levee, in the St. Louis World's Fair buildings, in "Lindy's" trophies on display, and in other interesting ways. Today's activity is impressively shown by busy, modern processing plants, ever-expanding businesses, bustling transport and growing residential areas. Although justly proud of its size and standing in many fields, St. Louis (like chemical engineering) has never been content to stand still. Based on a history of steady expansion and progress, its future is a promising one. In the minds of many rise visions of future improvements, perhaps best symbolized by the giant stainless steel arch which someday will shiningly dramatize the role of St. Louis as "Gateway to the West."

St. Louis is characterized by diversification of business activities and of the origin and temper of the citizenry. No single slogan, however true in itself, can fully describe St. Louis, variously called "City of Unlimited Possibilities," the "City Surrounded by the United States," and even "Grand Dame of the Prairies." By the same token, no single viewpoint can encompass it; one must take a "multiordinal" view.

Colorful Past

St. Louis was founded in 1764, when French pioneers established a new settlement in the wilderness on the west bank of the Mississippi. Teen-aged Auguste Chouteau directed the attack of their axes on the trees in the area blazed the year before by Pierre Laclede Liguest. Laclede, after a thorough exploration up and down the river, predicted for the site he chose "one of the finest cities of America," and his followers named it St. Louis in honor of French King Louis IX, the Crusader King. In three years, Laclede's followers had consolid-

Some pictures in the articles on St. Louis were supplied by The St. Louis Chamber of Metropolitan St. Louis and the St. Louis Convention and Publicity Bureau.

Left to right, seated: Charles W. Swartout, Mallinckrodt Chemical Works, general chairman; David S. Weddell, Monsanto Chemical Co., chairman, Publicity Comm. Standing: Richard J. Kozacka, Monsanto Chemical Co., chairman, Registration & Information Comm.; Willard P. Armstrong, Washington University, chairman, Student Program Comm.

ated their fur-trading activities with the larger Indian nations on both sides of the river and up to the Great Lakes, until their monopolies were secured against the attempts of the English to break them. From those tooth-and-claw days, fur trade became a bastion of St. Louis' prosperity which remains today, for St. Louis is still a central point for the collection of raw fur pelts, and the entire annual output of Alaskan seal skins is processed here.

St. Louis was soon the gateway for migration further west and the jumping-off place for many military, scientific and exploratory expeditions. Of these the best known is the 1804 Lewis and Clark Expedition. French St. Louisans went forth to found other cities and their activities led to the American occupation of Louisiana.

The Central and Southwest parts of the United States were acquired by the Louisiana Purchase in 1803. This vast territory was even larger than the combined area of the States existing prior to that time. In 1821 Missouri, destined to become the central state of the Union, was granted statehood. St. Louis was incorporated as a city two years later. The first wave of French settlers and the second one of frontiersmen and Forty-Niners rushing to the West were followed by a third wave of Germans: artisans, scholars, professional men, tradesmen and others, who lent a certain deliberateness to the quality of the city. The centennial of the Louisiana Purchase was celebrated in 1904 by the Louisiana Purchase Exposition, better known as the St. Louis World's Fair.

The city's beginnings and its frontier prosperity stemmed directly from its advantageous location on the mighty waterway called "Missi-Sepe" by the Indians. Into this "Big River," just above St. Louis, emptied the "Great Muddy Water" of the Missouri from which the state was to take its name. The river, down which young Abraham Lincoln was to float many raft-loads of his own hand-hewn rails, and of which Mark Twain was to write so unforgetably, saw its first steamboat in 1811. For a time, pirates swarmed the Mississippi, until tough river boatmen combined forces to drive them away. In those days hundreds of paddle-wheel steamboats noisily plied the river with their white cargoes of cotton, and St. Louis became the principal city of the West.

The Civil War abruptly ended trade with the South; then for some time after the war, rail traffic between East and West largely replaced the old-time steamboats from the South. Although St. Louis soon became and remained a leading rail center and later pioneered in air travel as well, river transport quietly grew again until today the city is a veritable inland seaport.

Visitors to the riverfront streets can conjure up visions of slaves being sold on the stone auction block before famous Old Courthouse, the scene of the historic Dred Scott case, and of Daniel Webster, Abraham Lincoln and Ulysses S. Grant passing by. Nearby still stands the home of Eugene Field, in whose mind Wynken, Blynken and Nod first sailed off into their sea of dew.

One of the finest chapters in St. Louis' more recent past was written in 1926 and 1927 by a man of vision and practicality — Charles A. Lindbergh. From his heroic first nonstop flight over the Atlantic to last glimpses of his silver "Spirit of St. Louis," winging east from St. Louis on its last flight before immortalization in the Smithsonian Institution, Lindbergh won and kept a special place in the hearts of St. Louisans. Typically, he left his fabulous collection of trophies and mementoes of the flight in St. Louis, where millions have seen them.

Much impressive data could be included in this article—if space permitted—about the postwar progress of Metropolitan St. Louis—e.g., its manufacturing expansion, with $150,000,000 going into chemical manufacturing expansion alone. Ranking sixth among the country's chemical centers, the St. Louis area produces a great variety of chemical products ranging from heavy chemicals and intermediates to extremely pure fine chemicals and pharmaceuticals. Also mention should be made of its $105,000,000 for commercial plant growth since 1945; its urban development and higher learning facilities. In fact chemical engineers attending the meeting will see many signs of the general growth, particularly in downtown establishments, their headquarters hotel, and in a number of the plants they will be visiting in the St. Louis area.

Brief descriptions of the St. Louis area plants for which plants trips have been scheduled in conjunction with the Dec. 13-16 meeting appeared in the October issue of "C.E.P." page 44.

Other chemical plants, process industries, and related businesses here which will be of interest to many visitors to the meeting are as follows:

• • The Blanton Co., pioneers in the manufacture of high quality oleomargarine, have installed a hydrogenation plant, and now extract, purify, and hydrogenate all their vegetable oil requirements.

• • The Dow Chemical Co. is keeping pace with the growth of the magnesium industry by starting operation of a new mill in Madison, Ill., for the production of magnesium sheet, plate, and strip, extruded shapes, tubing, rod and bar, and alloy ingots. The new rolling mill here will greatly multiply Dow's capacity with provision for even further expansion. Dow will also install at the Madison division the most modern extrusion plant for light metals in the United States. It will include presses ranging from 250 tons to 5,500 tons capacity.

(Continued on page 26)

Left to right, seated: Kenneth R. Hancock, C. K. Williams & Co., chairman, Hotel & Meeting Rooms Comm.; Robert E. Lenz, Monsanto Chemical Co., chairman, Housing Comm.; standing: Charles B. Roen, Monsanto Chemical Co., chairman, Finance Comm.; J. Harold Yeager, Mallinckrodt Chemical Works, chairman, Printing Comm.

Left to right: Stanley L. Lopata, Carboline Co., chairman, Plant Trips Comm.; Richard M. Edwards, Mallinckrodt Chemical Works; Mrs. S. L. Lopata, chairman, Ladies' Program Committee; J. Harold Yeager, Mallinckrodt Chemical Works, chairman, Printing Comm.

TECHNICAL PROGRAM

Monday, Dec. 14, 1953

TECHNICAL SESSION NO. 1

General Technical Program

2:00 P.M.—PROCESS INDUSTRIES OF ST. LOUIS, L. E. Stout, Sr., Washington University, St. Louis, Mo.

2:30 P.M.—BUBBLING PERFORMANCE IN RELATION TO DISTILLATION AND ABSORPTION, Ju Chin Chu, John Forgrieve, Robert Grosso, S. M. Shah, and D. F. Othmer, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

3:10 P.M.—PACKING PERFORMANCE BELOW AND ABOVE FLOODING, A. J. Teller, Fenn College, Cleveland, Ohio.

3:45 P.M.—DESIGN OF BUBBLE CAP TRAYS, Paul Munk, California Research Corp., Richmond, Calif.

4:20 P.M.—THERMAL CONDUCTIVITY OF THIN FILMS OF HYDROCARBONS, R. D. Sutherland, R. L. Davis, and W. F. Seyer, University of California at Los Angeles, Los Angeles, Calif.

TECHNICAL SESSION NO. 2

Productivity in Chemical Manufacturing

2:00 P.M.—YARDSTICKS OF PRODUCTIVITY AND THE USE OF THE PRODUCTIVITY CONCEPT IN INDUSTRY, Ewan Clague, Commissioner of Labor Statistics, Department of Labor, Washington, D. C.

2:45 P.M.—THE MEASUREMENT OF PRODUCTIVITY IN THE CHEMICAL INDUSTRY, R. F. Bruckart, associate professor, Industrial Engineering, A & M College of Texas, College Station, Tex.

3:30 P.M.—PRODUCTIVITY IN CHEMICAL PLANT MAINTENANCE, L. A. Darling and H. A. Bogle, Du Pont Co., Wilmington, Del.

4:15 P.M.—MANPOWER, Sydney Steele, director, Planning Staff, Atlas Powder Co., Wilmington.

TECHNICAL SESSION NO. 3

Processing of Coal and Oil Shale

2:00 P.M.—LOW TEMPERATURE CARBONIZATION OF COAL AND LIGNITE FOR INDUSTRIAL USE, V. F. Parry, U. S. Dept. of the Interior, Denver, Colo.

2:45 P.M.—ECONOMIC ASPECTS OF LOW TEMPERATURE CARBONIZATION OF COAL, R. G. Minet, H. B. Smith, Jr., and C. A. Trilling, United Engineers and Constructors, Inc., Philadelphia, Pa.

3:30 P.M.—THE GASIFICATION OF COAL-DUST AS A FACTOR IN THE TECHNOLOGY OF MODERN SYNTHESES, Friederich Totzek, Heinrich Koppers, G.m.b.H., Essen, Germany.

4:15 P.M.—THE DEVELOPMENT OF A CONTINUOUS GRAVITY-FLOW OIL-SHALE RETORT, Russell J. Cameron and Boyd Guthrie, U. S. Department of the Interior, Rifle, Colo.

Tuesday, Dec. 15, 1953

TECHNICAL SESSION NO. 4

General Technical Program

9:00 A.M.—MEMBRANE SEPARATION IN THE GASEOUS PHASE, Karl Kammermeyer and D. W. Brubaker, State University of Iowa, Iowa City, Iowa.

9:40 A.M.—THE "JERKED-BED" CONTINUOUS COUNTERCURRENT ION EXCHANGE CONTACTOR, I. R. Higgins and J. T. Roberts, Oak Ridge National Laboratory, Oak Ridge, Tenn.

10:30 A.M.—MASS TRANSFER AT ROTATING CYLINDERS, M. Eisenberg, C. W. Tobias, and C. R. Wilke, University of California, Berkeley, Calif.

TECHNICAL SESSION NO. 5

Distillation

9:00 A.M.—PROGRESS AND FUTURE PLANS OF THE A.I.Ch.E. PLATE EFFICIENCY RESEARCH PROGRAM, J. A. Gerster, department of chemical engineering, University of Delaware, Newark, Del.

9:25 A.M.—ENTRAINMENT FROM BUBBLE CAP TRAYS, P. T. Atteridg, E. J. Lemieux, W. C. Schreiner, and R. A. Sundback, The M. W. Kellogg Co., New York, N. Y.

10:10 A.M.—EFFECT OF LENGTH OF LIQUID PATH ON PLATE EFFICIENCY, M. F. Gautreaux and H. E. O'Connell, Ethyl Corp., Baton Rouge, La.

10:35 A.M.—TURBOGRID DISTILLATION TRAYS, R. B. Olney, Shell Development Co., Emeryville, Calif.

TECHNICAL SESSION NO. 6

Industrial Waste Treatment

9:00 A.M.—A REPORT ON THE ORGANIZATION OBJECTIVES AND ACCOMPLISHMENTS OF THE NATIONAL COUNCIL FOR STREAM IMPROVEMENT, Russell L. Winget, executive secretary, National Council for Stream Improvement, Inc., New York, N. Y.

9:20 A.M.—WATER BALANCE—A PRIMARY KEY FOR INDUSTRIAL WASTE CONTROL, A. N. Heller and M. E. Wenger, Barrett division, Allied Chemical & Dye Corp., New York, ,N. Y.

10:00 A.M.—INTEGRATED WASTE TREATMENT SYSTEM FOR THE METAL FINISHING INDUSTRY, Leslie E. Lancy, consulting engineer, Ellwood City, Pa.

10:30 A.M.—THE USE OF ION EXCHANGE IN THE WASTE TREATMENT FIELD, C. F. Paulson and A. B. Mindler, special applications department, The Permutit Co., New York, N. Y.

12:00 Noon—PROFESSIONAL PROGRESS AWARD IN CHEMICAL ENGINEERING LECTURE—Gold Room, Hotel Jefferson.

A CHALLENGE TO ENGINEERS, G. E. Holbrook, Du Pont Co., Wilmington, Del.

TECHNICAL SESSION NO. 7

General Technical Program

2:00 P.M.—A GENERAL PURPOSE SEMIPLANT FOR RESINS, F. C. Tuttle, The Dow Chemical Co., Midland, Mich.

2:30 P.M.—OPPORTUNITY FOR THE CHEMICAL ENGINEER IN STEEL INDUSTRY RESEARCH, T. F. Reed, United States Steel Corp., Pittsburgh, Pa.

3:00 P.M.—EXTRACTION OF OIL FROM SOYBEANS, D. F. Othmer and J. C. Agarwal, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

3:40 P.M.—VISCOSITY OF SUSPENSIONS OF SPHERICAL AND OTHER ISO-DIMENSIONAL PARTICLES IN LIQUIDS, A. P. Ting and R. H. Luebbers, University of Missouri, Columbia, Mo.

4:20 P.M.—TWO-PHASE CONCURRENT VERTICAL FLOW OF AIR-WATER AND AIR-KEROSENE MIXTURES IN CLEAR PLASTIC TUBING, W. C. Galegar, W. B. Stovall, and R. L. Huntington, University of Oklahoma, Norman, Okla.

TECHNICAL SESSION NO. 8

Distillation

2:00 P.M.—PERFORMANCE OF SEVERAL TYPES OF TOWER PACKINGS IN A 12-INCH DIAMETER DISTILLATION COLUMN, J. F. Ryan and M. R. Cannon, Pennsylvania State College, State College, Pa.

2:30 P.M.—EFFECT OF LOAD AND PRESSURE ON PERFORMANCE OF A COMMERCIAL BUBBLE TRAY FRACTIONATING COLUMN, H. A. Clay, T. Hutson, Jr., and L. D. Kleiss, Phillips Petroleum Co., Bartlesville, Okla.

3:00 P.M.—MASS TRANSFER STUDY OF BUBBLING IN RELATION TO DISTILLATION AND GAS ABSORPTION, J. C. Chu, John Forgrieve, and G. C. Papacosta, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

3:30 P.M.—DESIGN METHOD FOR BINARY BATCH RECTIFICATION, Charles E. Huckaba and R. S. Tour, University of Cincinnati, Cincinnati, Ohio.

4:00 P.M.—RELATIVE PERFORMANCE OF SIEVE AND BUBBLE-CAP PLATES, J. B. Jones and C. Pyle, Du Pont Co., Inc., Wilmington, Del.

TECHNICAL SESSION NO. 9

Industrial Waste Treatment

2:00 P.M.—THE PLACE OF AQUATIC BIOLOGY IN THE FIELD OF STREAM POLLUTION CONTROL, C. E. Renn, professor, Sanitary Engineering, Johns Hopkins University, Baltimore, Md.

2:35 P.M.—A NEW APPROACH TO PICKLE LIQUOR DISPOSAL, D. A. Dahlstrom, director of research, and R. O. Hawkes, Process Engineer, The Eimco Corp., Chicago, Ill.

3:10—OPERATING EXPERIENCE—CATALYTIC OXIDATION OF AQUEOUS WASTES, John Oliver, assistant manager, Belle Works, Du Pont Co., Charleston, W. Va.

3.45—RESEARCH IN INDUSTRIAL POLLUTION CONTROL, Roy F. Weston, sanitary engineer, The Atlantic Refining Co., Philadelphia, Pa.

4:20 P.M.—RECOVERY OF PHENOLICS FROM COAL HYDROGENATION PROCESS EFFLUENTS, Radcliffe G. Edmonds and George F. Jenkins, Carbide and Carbon Chemicals Co., South Charleston, W. Va.

Wednesday, Dec. 16, 1953

TECHNICAL SESSION NO. 10

Heat Transfer

9:00 A.M.—SURFACE VARIABLES IN BOILING, Claude Corty and Alan S. Foust, University of Michigan, Ann Arbor, Mich.

9:30 A.M.—THE EFFECT OF GAS EVOLUTION ON SURFACE BOILING AT WIRE COILS, F. P. Pike, P. D. Miller, Jr., and K. O. Beatty, Jr., North Carolina State College, Raleigh, N. C.

9:50 A.M.—STABLE FILM BOILING OF LIQUID OXYGEN OUTSIDE SINGLE HORIZONTAL TUBES

(Continued on page 99)

NATIONAL SURVEY QUESTIONNAIRE

ANALYSIS OF WRITE-INS

Lloyd B. Smith, G. E. Montes, J. A. Polack

The Charleston Committee on write-in analysis. Seated, left to right: C. W. Atkins, George F. Jenkins, George Sklar. Standing, left to right: M. E. Weaver, G. Fred Ours, Russel Van Cleve, John D. Ryan, R. G. Lilley, R. A. Kemmer. Not present: Charles L. Isbell, Jr., W. P. Stephenson, K. J. Gutshaw.

In the Questionnaires mailed out last December, there were opportunities provided for the members to write in their thoughts on various subjects. Of the 12,087 Questionnaires mailed out, 64.5% were returned completed as requested and 3,465, or 28.7%, were returned with written-in comments. The task of digesting the comments and extracting their message was undertaken by about forty members scattered throughout five local sections. This review brought out 5,150 comments, each of which could be placed into one to ten categories. It is the purpose of this article to present the substance of these comments.

Each of the reviewers made a record of those comments which they felt expressed some typical thought or some topic of special interest. They concluded their work by reducing the 5,150 write-ins to 1,658 recorded comments. About one eighth of these have been selected as representative of all the thoughts brought out in the write-ins. Rather than tell about them, we are reproducing these selected items in this article. They are separated into nine categories, for the tenth category contained those comments of "no added value." These consisted of alibis for not attending meetings, little personal confessions of various sorts, amplification of opinions already expressed in the Questionnaire, and scores of items about which the Institute could do nothing. There was another group of comments that were not included in the tabulations. These were the just complaints of those who were irritated because the Questionnaire did not fit the return envelope. We are in accord with their feelings and something can be done about this next time.

As each Questionnaire was received, the state from which it was mailed was written on it. The Questionnaires were then sorted by states and the reviewers maintained this division when considering the comments. Hence, we can tell whether geographical location enters into some of the comments. A summary showing some of the statistical information regarding the comments is given in Table 1. (See page 22.)

First of all, a few comments about the comments! While some of the "straight from the shoulder remarks" were solicited, most of them might be regarded as spontaneous expressions of topics that were uppermost in the minds of the writers. They may or may not apply to the membership as a whole.

The Baton Rouge committee, one of the five local-section groups analyzing write-ins. Seated, left to right: J. A. Polack, L. B. Smith, G. E. Montes. Standing, left to right: Gerry Westbrook, G. E. Golden, C. V. Foster, M. O. Gernand, E. A. Johnson, W. T. Boyd.

Such extrapolation would not be proper. Some of the thoughts might not have occurred to many. Several of the comments on membership and C.E.P. might well form the basis for another questionnaire and each member asked for an opinion on the thoughts brought out. It is difficult to retain the perspective of proportion when reading some of the comments, but the percentage represented by the remarks is low and this fact should be constantly borne in mind.

We should like to express our appreciation to those who supplied lengthy, well-prepared comments on some subjects. Several complete college curricula on chemical engineering were presented. There were a few bound reports on different topics. It is obviously impractical to reproduce those here, but we hope the authors will claim these suggestions so that they may be considered in more detail with the name of the author known.

To another group who boldly signed their names, regardless of the request for anonymity, we suggest that they also present themselves (in writing) to the appropriate committee of the Institute, or to the Executive Secretary, and discuss their problems. Some of the comments have already been referred to committees.

From the total comments in the categories listed in Table 1, we may pick the topics that are probably the most controversial in the life of the Institute. Chemical Engineering Progress or "C.E.P." excites the most interest. Our magazine is the window of the Institute and people want to suggest what goes into it. Some say it is too technical, others say it is not technical enough. There are outspoken comments on other subjects. We hope Van * will retain his sense of proportion as he reads these and, to his credit, as he publishes them.

Second in the number of comments, are the membership and election policies of the Institute. These opinions are more one-sided than in the case of "C.E.P." A large number feel that the nominating and voting privileges should be extended. The grades of membership also were the subject of much comment. There were several suggestions on Local Sections and, more important, eighteen requests for the establishment of local sections. Many feel that the National meetings are too large and that many of the papers are not suited to oral presentation. Public Relations, like virtue and prosperity, were favored by all. There were not many comments concerned with liberal arts and licensing of engineers, but some were of interest. All other comments were mild compared to those on professional and economic status. No punches were pulled. There were several interesting thoughts expressed in the group of miscellaneous comments.

The balance of this article consists of selected write-ins from the Questionnaires. They are classified as follows:

A. Comments on Membership Grades and Voting Procedures
B. Comments on C.E.P.
C. Suggestions for Local Meetings and Local Sections
Local Sections Wanted
D. Economic Status of Engineers
E. National Meetings
F. Public Relations
G. Liberal Arts
H. Licensing of Engineers
I. Miscellaneous Comments
J. A Letter Received

* Editors Note: Van is diminutive for Van Antwerpen, elephant-hided editor of "C.E.P." Throughout this article by means of footnotes, we intend to correct misstatements and misunderstandings in the comments in the hope it will create better understanding of Institute policy.

"Men in white" at Cleveland talk it over. Left to right: J. C. Sturm, J. A. Pursley, J. J. Lukes, D. J. Porter, R. C. Sutter, M. J. Skeeters.

Foreword

What would you do about reviewing the comments written into 3,465 Questionnaires?

This is what the Committee did. The Questionnaires were sorted into states, then divided into five groups. From a sample of approximately 100 Questionnaires it was determined that the comments would fall into a few classifications. Accordingly, these suggested classifications were sent to reviewers with approximately 700 Questionnaires each. Five local sections cooperated in this study:

Section	Coordinator
Baton Rouge	Lloyd B. Smith
Boston	Richard K. Flitcraft
Charleston	George F. Jenkins
Cleveland	David J. Porter
Oklahoma*	M. F. Wirges

No section reviewed Questionnaires from its own state. As a result of this study the comments were classified by number into the categories shown in Table I, and typical or special comments were recorded. There were 1,658 recorded comments. These were again reviewed and for this article, 198 were selected as representative.

* M. F. Wirges and his group will be shown in the December issue.

Comments on Membership Grades

Massachusetts—Directors should not be elected on "honorary" basis, but on basis of capacity to work.

Illinois—The society is backward in its relations with other allied societies. Voting and office holding privileges are restricted to active members. These tend to have graduated from the practice of engineering to the practice of management. Thus, the society does not truly represent chemical engineers.

Illinois—More junior member representation is needed on the national level, perhaps a junior member council responsible to the active member council.

Pennsylvania—I do not like farce of electing National Secretary. Prefer secretary should be appointed by Council, but not serve as a member of Council.

Tennessee—Retain membership after retirement without payment of dues.[1]

California—The Institute should reconsider limitations to membership in Junior, Associate and Active grades, i.e., I was over 35 when degree obtained and not eligible by reason of age for Junior membership nor due to experience for Associate or Active grade.[2]

[1] This is possible. Council, on request, does this for retired members.
[2] Associate membership is now available for chemical engineers with such qualifications.

A studious group from Boston working on the Questionnaire. Seated, left to right: W. M. Davis, R. K. Flitcraft, A. J. Lobdell. Standing, left to right: R. F. Cassidy, J. W. Cross. Not present: A. A. Andrews.

Arkansas—A requirement for active membership should be registration as a professional engineer in at least one state.

Florida—Attempt to interest each new graduate in Ch. Eng. into joining the Institute.[3]

[3] President now writes a letter to each new graduate.

Delaware—Decrease the conversion age from junior to active membership to 30 years of age.[4]

Ohio—The division of the A.I.Ch.E. into (1) active, (2) associate, and (3) junior memberships is the one great weakness in our organization. As one of the younger members of the A.I. Ch.E., I feel somewhat resentful towards such classifications. We have qualified for membership only to find that we are not on an equal footing because of our age.[4]

[4] Active membership is no longer tied to a certain age—experience is now the criterion.

Massachusetts—Eliminate junior membership or change present classifications of "junior" to "active," associate as is, and active to "senior."

Rhode Island—I believe that more credit should be given for teaching chemical engineering in the evaluation of data for active membership.

Idaho—Suggest that number of years required to obtain active status in A.I. Ch.E. be reduced. Losing members by present policy.

West Virginia—I prefer to see membership restricted to the elite of the profession.

Idaho—It is my opinion that a person who devotes himself solely to teaching chemical engineers is not eligible for active membership.

Illinois—I have been a member for over 35 years and I am over 70. I suggested to our directors—over 10 years ago—that there should be a class of Senior members—no dues—for all who have been members at least 25 years—and are over 65 or 70. I also suggested Life Memberships to anyone over 60—for a price.

Illinois—Facilitate the transition from Student member to Junior member. In my own case there is a considerable lapse of time before junior membership is acquired. In order to ease possible financial burden on persons making this

TABLE 1.—SUMMARY OF WRITTEN-IN COMMENTS

Most Populous States Arranged by Geographical Area

	1	2	3	4	5	6	7	8	9	10	11		
	Mass. Conn.	N.J. N.Y. Pa.	Del. Md. Va.	West Va. Ohio	Ill. Ind. Mich.	Tenn. Ky.	Mo. Okla.	Texas La. Ala.	Calif. Wash.	All Other States (Foreign Inc.)	Total		
Statistical Data													
Total questionnaires sent out	579	3605	976	1165	1313	412	566	1241	969	1261	12,087		
Total questionnaires received	340	2179	687	745	852	258	366	809	650	916	7802		
Total % return	59	60	70	64	65	63	65	66	67	72	64.5		
Total received with comments	147	981	262	334	384	137	161	339	309	411	3465		
% with comments	25	27	27	29	29	33	29	27	31	32	28.7		
												Typical and Special Comments	
Classified Comments					Number of Comments							Recorded	Selected
Grades of membership, nominating and election procedures	62	270	40	68	152	40	58	82	59	95	926	295	28
"C.E.P."	59	454	103	185	160	77	87	136	100	146	1507	515	47
Local sections and local meetings	23	193	38	93	51	54	68	85	40	65	710	212	34
Economic status	12	95	10	26	26	4	14	52	39	16	294	83	16
National meetings	11	42	0	3	15	4	8	0	12	34	129	106	18
Public relations	7	90	20	24	33	13	17	46	18	31	299	50	11
Liberal arts	0	23	3	11	7	2	3	11	6	3	69	22	4
Licensing of engineers	3	23	0	4	7	3	11	5	14	7	77	28	7
Comments on misc. topics	1	20	0	4	34	15	3	6	57	319	459	347	33
Comments of no added value	15	267	0	63	82	39	67	39	41	67	680	—	—
Total No. of individual comments	193	1477	214	481	567	251	336	462	386	783	5150	1658	198

transition right out of college, the initiation fee could be deferred until Associate or Active membership is acquired. Where graduates enter military service immediately after graduation their continuing interest could be retained by charging as the yearly membership fee only the price of C.E.P.[5]

Illinois—Reserve the Associate membership rank for those on the fringes of the profession.

Pennsylvania—Responsible charge requirement for active membership is no guarantee of professional attainment, but rather of management status. Work is probably divorced from engineering as such.

Pennsylvania—Some regional basis for at least half the directors should be adopted.

West Virginia—Several good engineers in department are not active; but department head, a chemist who knows practically nothing about chemical engineering, is active member. Doesn't seem fair.

Oklahoma—Not satisfied with the method of nominating and electing officers since only active members participate. From looking at the applications for membership in C.E.P. each month, the A.I.Ch.E. is apparently supported to a large extent by the dues of junior members who have no voice in Institute policies. This certainly is not fair.

Massachusetts—Run at least two nominees for each office.

Illinois—The Institute should have a nominating committee. Tie-in local sections.

New York—I object strongly to the directed campaigning by mail which has been practiced by some chapters and by the employees of certain companies for the selection of their candidates.

New York—Some relaxation of the rules for admitting teachers of Chemical Engineering as Active members should be made. A great deal of needless ill feeling is generated by refusing Active membership to qualified teachers, especially where they have had industrial experience or are, at present, acting as consultants to industry.

New York—Displeased with the current drive to enroll everyone in the chemical industry as a member or junior member of the Institute. What is gained by sheer weight of members? If we want the Institute to be a nice, dignified union like the A.M.A., then we should be more discriminating in our selection of junior, and especially active members.

New York—Junior should have one-quarter, Associate one-half vote.

Comments on C.E.P.[6]

Washington—Believe the C.E.P. and the conventions could be of more general interest to more people (not just students, professors, and design engineers) if the topics would deal more with end items and not quite so much with unit processes and design data.

[5] Armed forces—no dues; C.E.P. for members price of $4.50.

[6] "Steel yourself, Van."

California—The editors of C.E.P. should continue, but with renewed vigor to eliminate that type of paper which offers nothing except a work-out in mental gymnastics.

California—I would enjoy seeing more articles relating to the practical aspects, say 50-50, and provide reprints of technical articles for a nominal fee with only abstracts appearing in C.E.P.

Delaware—C.E.P. concentrates on highly theoretical articles. There should be more articles on commercial processes, etc.

California—C.E.P. offers little of interest to production foremen or supervisors in chemical manufacturing.

California—C.E.P. should devote itself to highly technical articles and avoid semi-technical and news articles. Other magazines can carry these. Should avoid semi-advertising description of commercial equipment.

California—Articles in C.E.P. of interest to specialists only—should get articles of broad scope.

Ohio—Is there a way to simplify subject matter in C.E.P. so that it can be read and understood by the average chemical engineer? Several of my chem. eng. friends feel as I do on this point. Most of the subjects are up in the stratosphere for us.

Ohio—I realize that primarily the A.I.Ch.E. attempts to promote the publication of highly technical papers. However, I believe that this survey will show that such a program is at the expense of a large share of the membership who are employed where design calculations and such subjects are of little or no use to them.

Ohio—A large number of Ch.E.'s are either "Technical Service Engineers" or "Sales Engineers." How about some coverage of these fields in program and C.E.P.?

Illinois—C.E.P. should publish articles dealing with other sciences (electronics, physics, chemistry and mathematics) so that pertinent developments in these sciences can be used to broaden chemical engineering.

West Virginia—Many magazines treat the broad subjects of industry but "C.E.P." is one of the few to retain an academic and theoretical view in its articles. This academic discussion should certainly be retained and enlarged upon.

New York—The bulk of the papers presented in C.E.P. seem to be of a theoretical nature. Though there is a distinct need for this information, it is, I believe, not as valuable as more practical articles to the average Chemical Engineer. I should like to see a greater percentage of articles covering such topics as: corrosion, materials of construction, practical solutions to problems common to the various unit processes and operations.

New York—Believe C.E.P. could improve by reducing the number of articles which give extended mathematical treatment and derivations to some of the technical data offered. Although excellent for the specialist or student just out of college, I don't believe these articles are of general interest.

California—I am constantly annoyed at the absence or scarcity of basic technical material in C.E.P. Too much space is wasted on articles about economics of this, that, or the other; market research; and selling. This space could more profitably be used for technical articles.

Washington, D. C.—C.E.P. should be kept as is. Most A.I.Ch.E. members belong to the A.C.S. and receive C. & E. News for information of a political or economic nature.[7]

New Jersey—Suggests making long tables of data which appear in C.E.P. available to those who want, but not to publish, which will provide room for more articles.[8]

Ohio—C.E.P. should publish abstracts of more technical papers and devote less space to long specialty projects.

Ohio—Suggest that C.E.P. publish a short abstract of each paper presented at regional or national meetings. The reprints should be available, at a fee.

Ohio—Why not have optional subscription to C.E.P. by members.

New York — Chemical Engineering Progress could stand a picture on the cover—if it could stand the extra cost. A modern or recent installation of equipment or a processing plant, refinery, etc., would be attractive.

New York—I am not prepared to say that technical content of C.E.P. should be reduced since some publication must do this job and it is definitely a prime responsibility of the Institute to see that it is done. Enlarging the size and broadening the base of C.E.P. would make it more valuable to one—but there are other publications to supplement it so we should not be hasty in recommending a change.

New York—Start and complete articles on successive pages for ease of removal and filing. Do not continue articles in the back of the book.[9]

New York—Consideration should be given to two publications; one of a professional character without advertisement, and the other with general interest articles, news section, editorials, and advertisement.

New York—I would like to see Transactions revived to give the former excellent presentation of technical matter. A separate "newspaper," which would include advertisements, etc., should be used for Institute news, feature articles of less-than-technical nature, etc. I would be willing to pay for this Transactions edition. I would bind and save it; I presently throw C.E.P. away after several months.

New York—Please do not turn C.E.P. into a 500 page unreadable monster such as the other chemical engineering journals are.

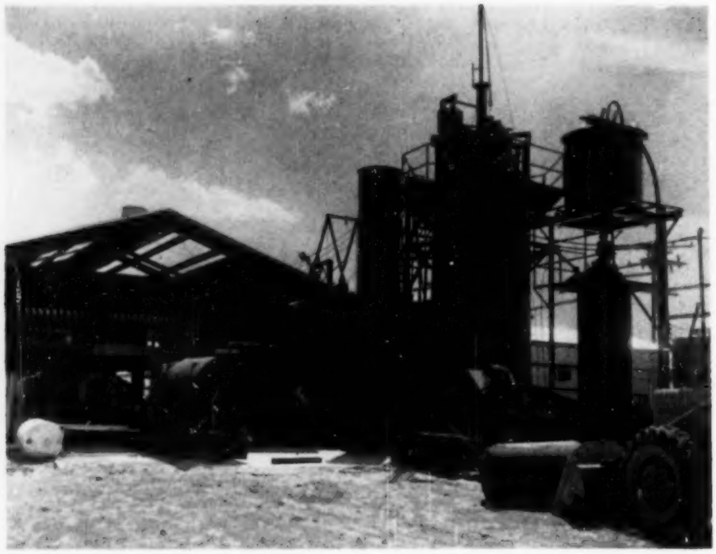
Texas—Do not permit C.E.P. to become an advertising medium.

[7] A problem to the editors. Only 51% A.I.Ch.E. members belong to A.C.S., down since 1947 from 59%.

[8] We try now to place all lengthy tables on file with American Documentation Institute.

[9] Only done in news section.

(Continued on page 30)



Open-end view of the Salt Lake Tungsten Co. plant showing the process equipment used to produce synthetic scheelite from the residues of the World War II government operation. A pressure-type filter permits quick opening and cleaning and improved washing facilities.

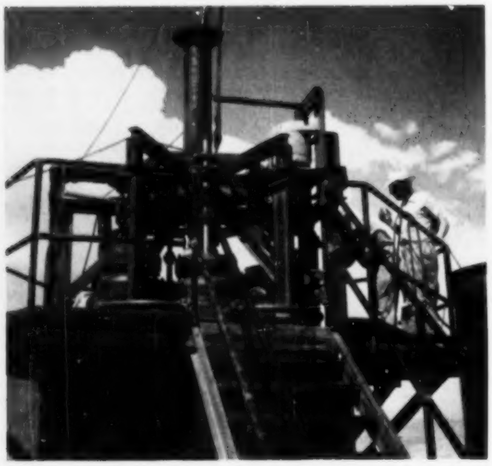
A new processing company, the Salt Lake Tungsten Co., formed by the Minerals Engineering Co. and Sylvania Electric Products Co., has completed a $300,000 refinery and is now producing tungsten from residues left from a government-owned World War II plant. Production according to company officials will reach 200,000 lb. a month.

Originally the government owned a tungsten plant in Salt Lake City, the Metal Reserve Co., which at the end of World War II was declared surplus and was dismantled. The discarded residues containing tungsten, the raw material for the new plant, were dumped on the western outskirts of the city. These residues are now being solubilized under high pressure.

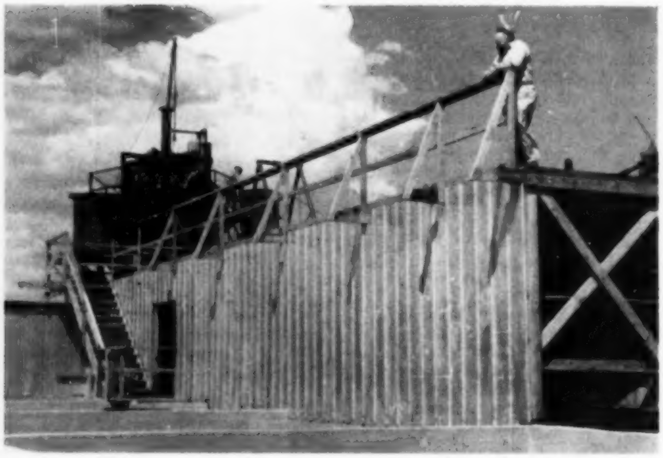
The new plant, its engineers believe, can concentrate ores running as low as 0.4% tungstite a ton and can operate commercially on concentrates with heads of 5%. Besides the tungsten residues, ore from local deposits within a radius of 200 miles of Salt Lake City will be refined in the new plant. The most prevalent tungsten-bearing ore in the vicinity is scheelite.

President of the new company is Blair Burwell, who is also head of Minerals Engineering Co. He formerly operated the government-owned tungsten plant that produced the raw materials used by the new plant.

World War II Tungsten Residues Processed



Close-up of reactor, which is operated in a vertical position to conserve heat and prevent dilution of the solution. A pressure of 240 lb. forces the slurried ore through the reactor into the surge tank. Each reactor is equipped with a heat exchanger.



Separation vats shown outside the housed units.

ST. LOUIS STORY

(*Continued from page* 18)

• • The Fouke Fur Co. employs processes of considerable chemical interest. A unique industry, it processes and conducts auctions of the Alaskan seal pelts for the U. S. and Canadian governments, many more from South Africa, and others for the Uruguayan government.

• • Lever Brothers Co. has had completed the streamlined, modern first unit of a new manufacturing and distribution center in Pagedale, Mo. The first unit is a detergent plant which produces the company's three popular detergents. The company has been an important establishment in St. Louis, industrial life since 1839. During World War II, the plant made thousands of tons of G.I.-type soap and large quantities of glycerine used in the manufacture of explosives for the armed forces.

• • Mallinckrodt Chemical Works was founded in St. Louis in the fall of 1867 to engage in the production of fine chemicals, particularly those for medicinal use. Today the company's activities include the manufacture and sale of a general line of fine chemicals for medicinal, photographic, industrial, and analytical purposes and the production of uranium and uranium compounds for the Atomic Energy Commission. Mallinckrodt Chemical Works has pioneered in developing the highest possible grade of ether for anesthesia and x-ray contrast media. The company was cited in the Smyth Report for its fine work in producing uranium for the Manhattan Project during World War II. The firm supplies chemicals used in the production of phosphors for fluorescent lighting and television tubes, and chemicals for other electronic uses.

• • Midwest Rubber Reclaiming Co. was organized in East St. Louis, Ill., in 1928 and is now the country's largest independent reclaiming company. Careful chemical and physical control testing of reclaimed rubber is made while in process and when finished.

• • Olin Industries, Inc., one of the largest industrial enterprises in the St. Louis area, has its headquarters and one of its larger plants at East Alton, Ill. From the original Olin Co. founded there in 1892, Olin Industries has become one of the more diversified of the country's "growth" companies and now has nine separate manufacturing divisions with eighteen plants in fourteen states. The bulk of Olin products is based on chemicals or metals.

• • The Wood River, Ill., refinery of Shell Oil Co. started with a capacity of 22,000 bbl./day of crude oil in 1918 and is now completing an expansion program which will bring its capacity to 170,000 bbl./day in 1954. The complexity of its operation requires the services of 3,700 people, among whom chemical engineers play an important part. The newer refining processes include a large catalytic naphtha-reforming plant which will use platinum catalyst.

• • Sinclair Refining Co., Inc., Hartford, Ill., is one of seven refineries operated by Sinclair Oil Co. Built in 1941 as the Wood River Oil & Refining Co., it was bought by Sinclair in 1950. They have a Perco re-forming unit, a U.O.P. polymerization unit, a fluid catalytic cracking unit whose capacity is 10,000 bbl./day, and a 10,000 bbl./day SO_2 extraction unit. The total plant capacity is 30,000 bbl. of crude oil a day.

• • Standard Oil Co. of Indiana operates a refinery at Wood River, Ill., whose crude oil capacity has been increased since the war to 42,500 bbl./day. More recently chemical facilities have been added there for the production of motor oil additives and synthetic detergents.

• • The Tretolite Co. (a division of Petrolite Corp.) is located in Webster Groves, Mo. Using both heavy and fine chemical raw materials, this company employs complex manufacturing procedures to produce effective demulsifying chemicals sold under the trade name Tret-O-lite, throughout oil fields of the United States and many foreign countries. Its demulsifiers are used to dehydrate emulsified crude oils. The Tretolite Co. is the largest supplier of chemical compounds used in chemical desalting processes at oil refineries. Tretolite also manufactures organic corrosion inhibitors, sold under the trade name Kontol, which are widely used by the oil industry in both the production and refining of crude oil.

• • Universal Match Corp., Ferguson, Mo., founded in 1926, has experienced prodigious and consistent growth. The world's largest manufacturer of special design book matches, its Armament division produces pyrotechnics like igniters and parachute flares.

• • The C. K. Williams & Co., East St. Louis, Ill., plant converts basic raw materials, including scrap iron, sulfuric acid, and alkali by a complex chemical process to a wide range of synthetic oxides in fundamental colors—yellows, reds, browns, and blacks. Natural iron oxides are processed into economical pigments of less brilliant hues. The paint industry is one of the principal users of iron oxide pigments. Large quantities are also used in the manufacture of linoleum, as well as in the rubber industry, and for metal and glass polishing.

• • Allied Mills has a highly modern solvent extraction plant for soybean oil and fat technology. • Alton Box Board Co. in Alton, Ill., has a complete plant for the production of cardboard from scrap paper or straw. • General Chemical Co. in East St. Louis, Ill., makes sulfuric acid; also produces alums from its own high-alumina clay. • Hunter Packing Co. has a modern tallow plant and renders out under vacuum in steam-jacketed cookers that double as heptane-solvent extractors. • Laclede Packing Co. has a similar installation. • The Illinois Farm Supply Co. completed a superphosphate and mixing plant at Collinsville, Ill., a few years ago. • A similar installation is operated in St. Louis County by the Missouri Farm Association.

Many of the chemical process industries in the St. Louis area concentrate on specialty products.

Besides its role as a great producer of chemicals and chemical materials, the St. Louis area is a major chemical consumer with more than 300 compounding companies in the local market and many auxiliary industries serving the chemical and process businesses here.

Chemical engineers whose wives "haven't a thing to wear" should by all means bring them to St. Louis. Many smart, exclusive shops as well as huge department stores purvey the creations of 291 apparel and related companies here.

On the subject of food—some of the products of 701 food production establishments here are embellished by many local restaurants and hotel dining rooms and elegantly listed on menus produced by some 436 printing, publishing, lithographic, and graphic arts establishments. Speaking of restaurants, visiting chemical engineers, ladies, and students will have a wide choice of cuisine in downtown St. Louis alone during the Dec. 13-16 meeting, and an even greater one if they venture farther afield. Among many downtown choices are the dining rooms of the Hotels Jefferson, Lennox, Mayfair, and Statler, Carl's Rio Room, the two excellent Miss Hullings' Cafeterias, Jim Mertikas' Grecian Garden for matchless steaks, the Orient for Chinese-American dishes, and old German Schumacker's.

Good restaurants farther out include unique Bevo Mill, a Dutch windmill featuring live lobster; Bistro N'Orleans; the new Chantilly Room with its soft music and gourmet's menu; Edmonds' for sea food, steaks, and chicken; Fredrik's; La Casa De Los Toros for enchiladas, tacos, and other Mexican food; Bill Medart's clustered Olde Cheshire, Great Hall, and Rose and Crown dining rooms; Pagliacci's

(*Continued on page* 98)

QUESTIONNAIRE

(Continued from page 23)

Texas—Diversify C.E.P. articles and concentrate specialized work in separate symposia.

Florida—C.E.P. should have a more distinctive title.

Illinois—Concerning C.E.P.: Keep all ads separated from the technical matter. Avoid single column text flanked by advertisements. Move stiff data cards to paper before final cover. Have Editorial Staff write a concise summary to be placed at beginning of every article, include conclusions.

Pennsylvania—I don't like stiff cardboard Data Service insert sheets; they interfere with turning the pages. I think more people would tear out a coupon and enclose it in an envelope.

Texas—Desire more attractive format for C.E.P.

California—Would like more information on how to provide safety procedures for storage and use of chemicals in small company.

Texas—Suggest Personnel and Safety Section for C.E.P.

Ohio—Let's keep the Institute constantly working for the economics and technical advancement of the individual engineer. And please don't let the C.E.P. become a trade journal as—has. C.E.P. should be reserved for news of the Institute and its members and for technical topics of interest to the individual members.

Ohio—Concerning additions to C.E.P.—I find it difficult to pay for and read all literature already crossing my desk. Give us what we don't already find in others. Allow us a few hours per week for normal living.

Massachusetts—Coordinate publication of A.I.Ch.E. and A.C.S. to avoid competition. Work out cooperative arrangement so members of both groups could subscribe to opposite publications at discount.

Massachusetts—There are enough trade journals like — and — floating around without depreciating C.E.P. with nonpermanent material.

Kentucky—More of C.E.P. costs should be borne by advertising.[10]

Missouri—Suggest local section correspondents be trained to yield more information in a better and more attractive manner to C.E.P.

Missouri—The Institute and C.E.P. are either unaware or largely unconcerned with the sizeable number of Chem. Eng. who no longer calculate "distillation columns."

Missouri—Editorials in C.E.P. show more intelligence than similar ones in some other engineering magazines.[11]

Maryland—Suggests C.E.P. articles be proportionally divided into those interests to the different groups making up the A.I.Ch.E.

West Virginia—Institute should publish two magazines; one technical, the other news. The news edition would be part of dues and the technical optional.

California—Employment ads in C.E.P. should list location of firm and name of firm. Should be mandatory. A man hates to spend hours in sending off a presentable resume of his career and then find out the job is in an unsuitable location or is the firm by whom he is already employed.

Massachusetts—C.E.P. should provide active employment clearing house.

Iowa—Devote space in C.E.P. to employment situation as well as a periodic survey of employment trends by region and industry. This would reveal local oversaturation.

NOTE: There were several suggestions about the type of articles wanted. They were too numerous to publish, but the comments have been sent to the Editor.[12]

Suggestions for Local Meetings and Local Sections

California—Every Local Section should have a "Welcome Committee."

Ohio—To improve attendance at local sections, greater efforts should be made to interest engineers who do not belong to the national organization. Meeting notices to these engineers as well as membership in the local section should be encouraged even though they might not care to join the national organization.

Delaware—Local sections should limit membership to a maximum of 200 so that the members will derive as much benefit from the organization. If necessary have more than one local section in a densely populated area.

Ohio—Nonnational members are admitted to the local section meetings and enjoy the benefits of the A.I.Ch.E. without contributing their share of expenses by becoming national members. This is unfair.

Miscellaneous—Call on local sections more to carry national load.

Oklahoma—The Institute should sponsor speaking tours by prominent men in the profession (my local section, for example, cannot afford to pay speakers' expenses, hence must depend on local speakers or speakers trying to sell something).

Washington—The national dues of membership should include the allocation for Local Chapter membership. I believe this would encourage closer relations across the country.

Ohio—I like the professional contacts promoted by A.I.Ch.E. membership and activity. This is mostly at local section level and local section activity should be stimulated by all possible means.

New Mexico—List addresses of all local sections in C.E.P. sometime.

Illinois—The section seems to have no adequate program or interest in introducing recently admitted members into the ranks. I am one of those who would like very much to become active in the organization.

West Virginia—The Charleston Section has been arranging study courses over the last two years which are very profitable.

Canada—Lack of interest from National A.I.Ch.E. towards fostering locals in Canada will probably lose A.I.Ch.E. considerable number of members.

Local Sections Wanted

Florida—No local section exists.

Delaware—Create more local sections in densely populated areas.

Ohio—Local section should be formed in the Dayton, Ohio, area.

Utah—Would like to join a local section if enough men could be interested.

Louisiana—Wishes to start local section.

Kentucky—Too far to go to attend local meeting. (Several indicated no local section in Paducah.)

Oregon—The nearest local section is 300 miles away in Seattle. May be as close as 100 miles.

Oregon—Seattle section too far away. Might be able to assist in getting local section started if an outline of organization requirements available.[13]

Oregon—Interested in seeing a local section started in Portland. Number of interested individuals.

Iowa—Iowa could support an active chapter centered about Ames or Cedar Rapids.

Idaho—We are trying to establish a basis for a local section in Idaho Falls. I favor more help from national A.I.Ch.E. in regard to local sections.

Illinois—Local meetings are inconvenient to attend owing to traffic. Chicago, particularly southeast area, could support another chapter.

South Carolina—Need local section at Sovanch River Project.

New York—Form Local Section in or near Syracuse, New York.

Washington—The A.I.Ch.E. could do much to strengthen its position in the northwest. Establish a local in the Portland area.

Texas—No Local Section in the Dallas-Fort Worth area.

Wyoming—We need a local section in Worland, Wyoming.

Canada—Any local sections in Toronto area?[14]

Norway—I live in Norway, I can't be a member of a Local Section.

Venezuela—No Local Section to my knowledge.

Mexico—No local section in Mexico D.F. Some friends and myself have been trying to organize a local section but up to date have not been successful because of small number of associates. Nevertheless we expect to continue our efforts.

France—No local section.

[10] **Selling advertising is a highly competitive business. See editorial C.E.P. June of this year.**

[11] **Ah! And from Missouri! The editor lives in New Jersey; did not send in this comment.**

[12] **Thanks, everyone. See editorial this month.**

[13] **Curry Ford, chairman of Local Sections, will be in touch. In past 10 years 31 local sections have been added, an increase of 450%.**

[14] **None yet.**

(To be continued)

G. E. Holbrook

L. Bromley

1953 Award Winners

R. Cartier

D. Sundstrom

Three of the Institute awards to be presented at the Awards Banquet on December fifteenth, during the Annual Meeting in St. Louis, have been announced. George E. Holbrook, assistant director, development department, E. I. duPont de Nemours & Co., will receive the Professional Progress Award; LeRoy A. Bromley, associate professor of chemical engineering at the University of California, Berkeley, has won the Junior Membership Award; and the A. McLaren White Award for the best solution to the student contest problem will go to Raymond M. Cartier, graduate student at Brooklyn Polytechnic Institute. The recipient of the William H. Walker Award for distinguished contribution to chemical engineering literature will be announced in the December issue.

Professional Progress Award

The Awards Committee under the chairmanship of Olaf A. Hougen has announced that George Holbrook was granted the Professional Progress Award in chemical engineering "for his remarkable record as a chemical engineer in his successive positions of directing research, development, and plant production of organic chemicals and for his energetic public services in advancing the profession of chemical engineering." This award, which consists of a certificate and $1,000, is sponsored by Celanese Corp. of America and administered by A. I. Ch. E.

Dr. Holbrook has been with DuPont since he received the Ph.D. degree from the University of Michigan in 1933. Starting as a research chemist, he became automotive engineer; head of new products division; general superintendent, Chambers Works, Jackson Laboratory; assistant technical director; manager of plants development, organic chemicals department, and finally assumed his present position in 1951.

In 1952 he was on loan to the government as the director of the chemical division of the National Production Authority

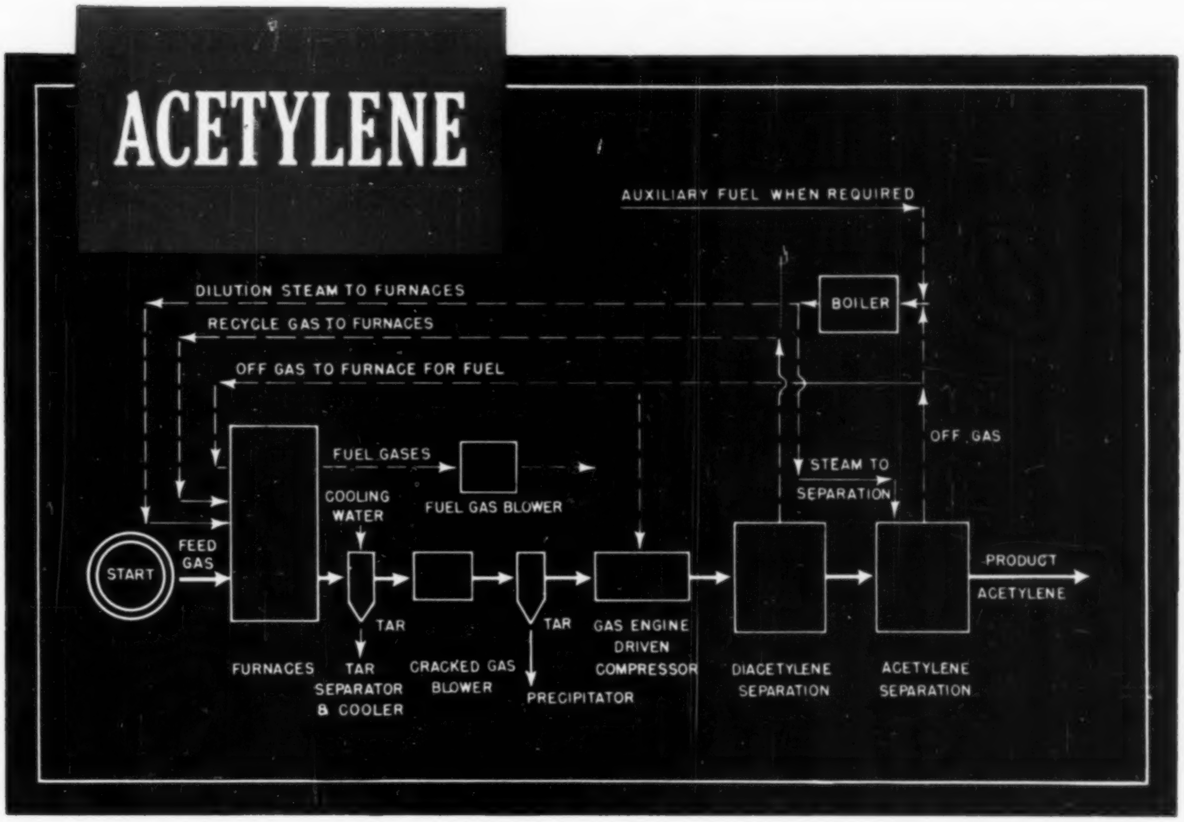
Dr. Holbrook's contributions to the field in general cover six patents for processes producing organic chemicals and a number of papers including three on metal polishing, entrainment in distillation column, and effect of metals on deterioration of motor oil.

He has been a director of A.I.Ch.E. and is now chairman of the Committee on the Future of the Institute. Other affiliations include the A.A.A.S., the New York Academy of Science, the American Physical Society, A.C.S., A.S.T.M., the Armed Forces Chemical Association, the Society of Chemical Industry, the Franklin Institute, and Tau Beta Pi, Sigma Xi, Phi Kappa Phi, Phi Eta Sigma, and Phi Lambda Upsilon.

Junior Membership Award

The Junior Membership Award was granted to LeRoy A. Bromley "for two papers judged most outstanding of those published in Chemical Engineering Progress by Junior Members of the American Institute of Chemical Engineers during the three-year period 1950-52." These papers were "Heat Transfer in Stable Film Boiling"

(*Continued on page* 44)



COST OF 5¢ PER POUND

shown by studies of acetylene process

GIRDLER economic studies of Wulff Process pilot plant data indicate that high purity acetylene can be produced by this process at substantial savings over the calcium carbide method. In one case, with natural gas feed, total acetylene cost is 4.82 cents per pound including plant depreciation. In another with propane feed, cost totals 6.41 cents per pound. The studies are based on a production of 20 million pounds per year of 99.5% purity gaseous acetylene.

All of the energy required for cracking natural gas, propane or butane is supplied by utilizing off-gas in efficient regenerative furnaces. Since availability of low-cost power is not a factor, these plants can be located wherever desired. With additional separation equipment, by-product ethylene can be produced.

For complete details on these studies of the Wulff Acetylene Process write or call our nearest office and ask for copy of "History and Economics of the Wulff Acetylene Process."

GIRDLER DESIGNS processes and plants
GIRDLER BUILDS processing plants
GIRDLER MANUFACTURES processing apparatus

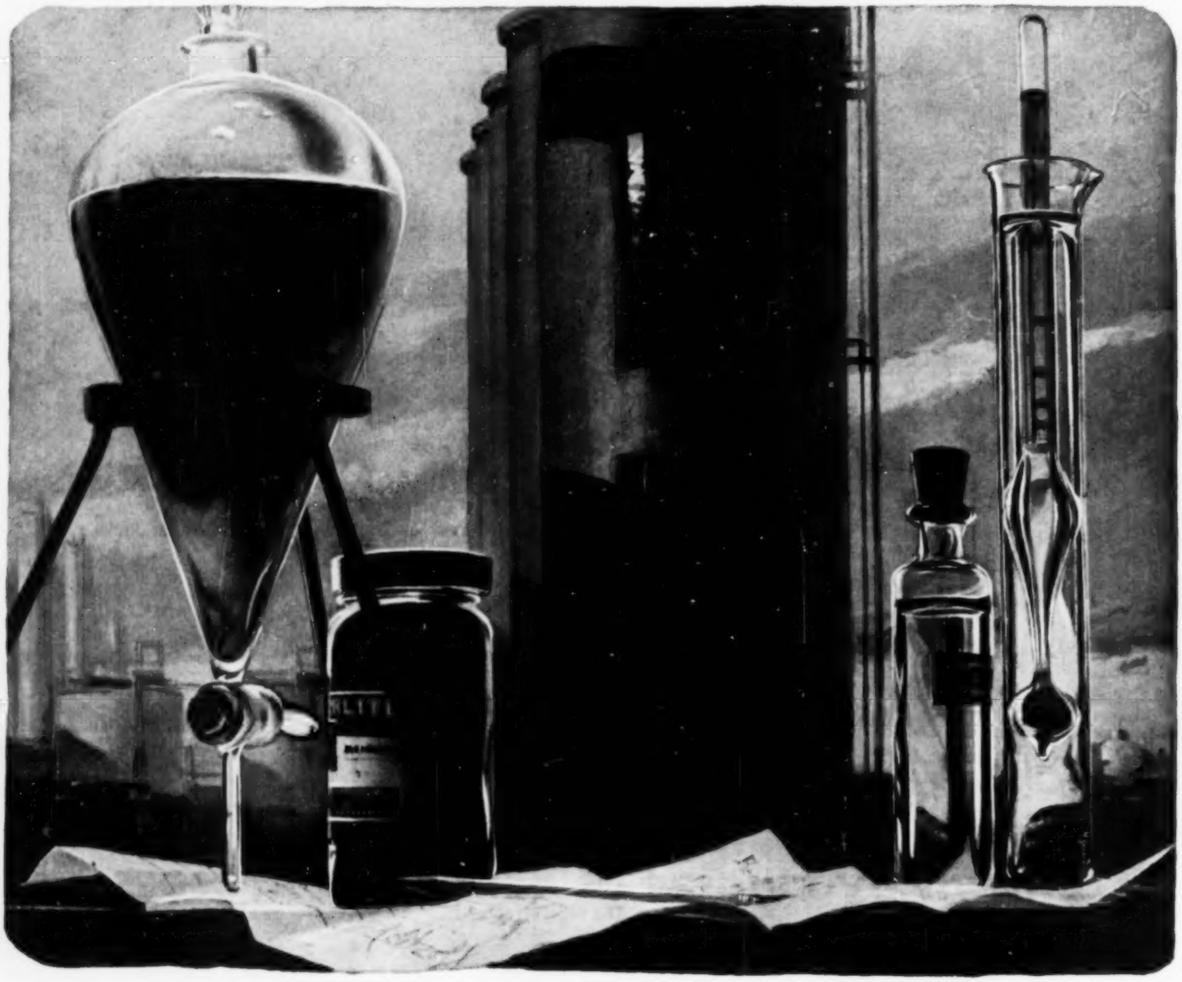
GAS PROCESSES DIVISION:

Chemical Processing Plants
Hydrogen Production Plants
Hydrogen Cyanide Plants
Synthesis Gas Plants
Plastics Materials Plants
Sulphur Plants
Acetylene Plants
Ammonium Nitrate Plants
Ammonia Plants
Catalysts and Activated Carbon

The GIRDLER Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

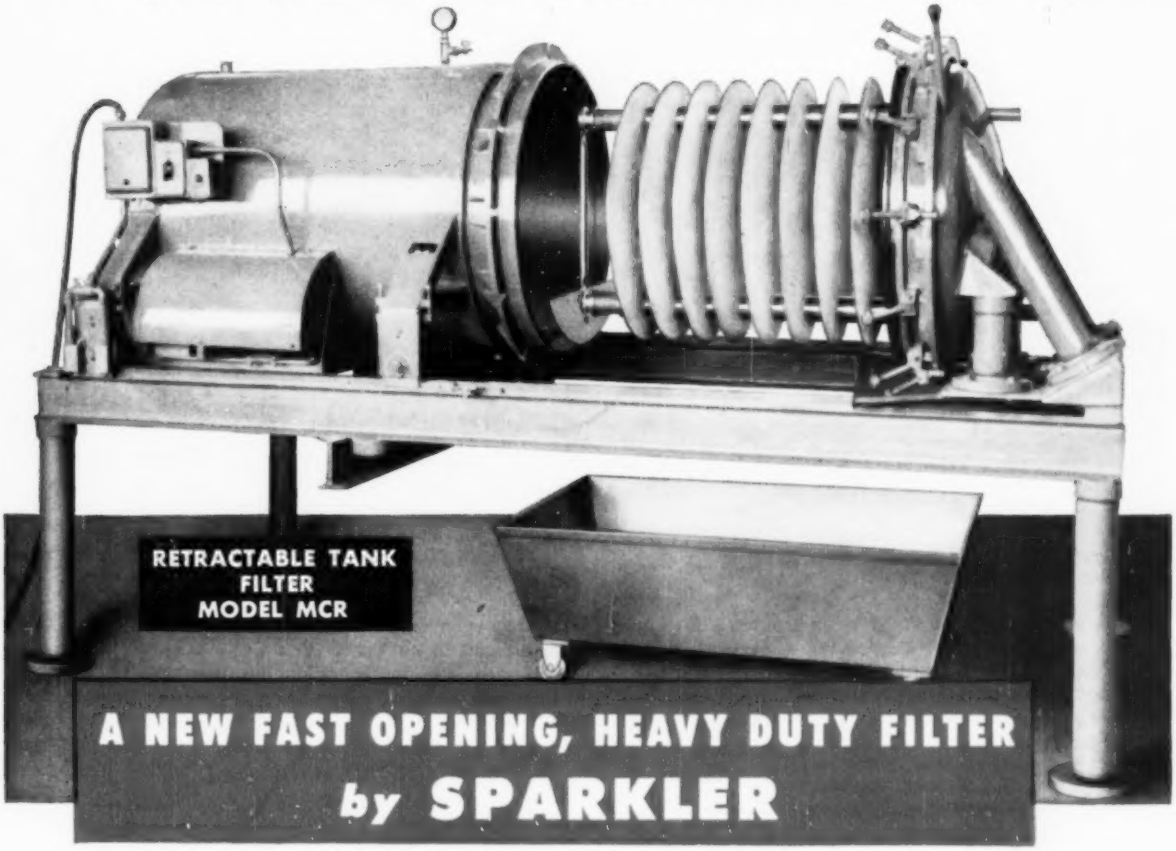
GAS PROCESSES DIVISION: New York, Tulsa, San Francisco
In Canada: Girdler Corporation of Canada Limited, Toronto, Ontario



BIG NEWS AT THE EXPOSITION

SEE BOOTH No. C-54

A New 1,000 sq. ft. Push Button Control Filter will be demonstrated



60 Second opening or closing without disconnecting piping.
Available in sizes from 100 to 2000 sq. ft. filtering area.

This new retractable tank model MCR filter opens up a new phase in filtering that will lower the cost materially in many industrial fields.

One movement of a handle, a flip of a switch and the retractable tank moves back, stopping automatically, leaving the plates exposed for hand cleaning. All in less than 60 seconds. Pipe connections are all in the stationary filter head so no disconnecting of piping is necessary. This gives you the fastest action, time-saving, labor-saving tank opening ever engineered in a filter.

Jet spray tubes can be supplied in this filter with automatic breaking head seal for water supply. With the jet spray the cake can be washed off with pressure spray, backwashed, or a combination of jet spray and backwashing employed for cleaning the plates.

The retractable tank Model MCR Filter fills the need for a large capacity filter that can handle heavy residue fluids and for removal of large percentage solids. The plates can be spaced any distance apart to accommodate a heavy or thin cake depending on requirements.

The circular double surface screen plates are reinforced to withstand extremely high filtering pressure without danger of collapsing.

Filter tanks can be supplied in mild steel, stainless steel, or other metals to meet chemical requirements. Tanks can be rubber lined or plastic lined for corrosion resistance. Each filter including valves and piping is engineered to perform the job required.

SPARKLER **MANUFACTURING COMPANY • MUNDELEIN, ILLINOIS**

Sparkler International Ltd.
Prinsengracht 876, Amsterdam, Holland

Sparkler Western Hemisphere Corp.
Mundelein, Ill., U.S.A.

MARGINAL NOTES

News of Books of Interest to Chemical Engineers

It's Lead—But Not Too Heavy

Lead in Modern Industry. Lead Industries Association, New York 17, N. Y. (1952), 223 pp. $1.50.

Reviewed by W. E. Alexander, Director, Process Engineering, Monsanto Chemical Co., Texas City, Tex.

This is a comprehensive treatment of modern applications of lead, lead alloys, and lead compounds. A brief history of lead and descriptions of mining, smelting and refining processes lend background to the chapters on specific applications which follow. The chemical engineer will find use particularly for the chapters *Lead in Modern Chemical Construction, Corrosion Resistance of Lead and Lead Alloys, Lead Oxides, Tetraethyl Lead,* and *Physical Constants of Lead Compounds.* A chapter on *Safe Handling of Lead and Its Products* covers toxicological aspects with references to more detailed literature, a useful reference for those involved with handling lead, its alloys or compounds.

Subjects of lesser interest to chemical engineers in this book include the uses of lead in radiation protection, modern architecture, modern plumbing, protective coatings, bearing metals, storage batteries, ammunition, and numerous alloy applications. A complete tabulation of various specifications for lead, lead alloys, and lead products is included.

The book is a combination of informative literature, reference, and handbook for lead, its alloys and compounds. It has been well edited for simple and direct treatment of the subjects presented. The inclusion of numerous photographs, drawings, and graphs contributes significantly to clear understanding of the text and tabulations.

Manual on Industrial Water. Prepared by A.S.T.M. Committee D-19 on Industrial Water. American Society for Testing Materials. Philadelphia, Pa. (1953), 336 pp. $4.25.

This is a brief reference source of information for three types of users: executives and plant designers; individuals engaged in industrial operations involving the use of water; and analysts, operators of special instruments, engineers, and consultants. The first two chapters give general information regarding utilization of water by industry. Chapter III provides a transition to the more technical portion: Chapter IV discusses the applicability and nature of various physical, chemical, and combined treatments. Chapters V to VIII give the details of the procedures and precautions to be observed in sampling, analysis, and examination of water.

Review of Current Research and Directory of Member Institutions. Edited by V. E. Neilly. Engineering College Research Council of the American Society for Engineering Education (1953), 330 pp., $2.50.

The latest issue of the Society's Review of Current Research gives a picture of all research programs at all of the member colleges. Approximately 100 institutions are included with a report on 7,500 research projects. The number of people engaged in these projects include more than 13,000 faculty, graduate students, and research engineers. Expenditures approximated $65,000,000 annually. The fields of research covered include all branches of engineering and most related fields. Other information contained in this book includes names of responsibile administrative officers.

Books Received

The Joining of Metals. The Institution of Metallurgists. Lectures delivered at the Institution's Refresher Course 1951. (June, 1952), 174 pp., 14/ each.

The Metallurgy of the Rarer Metals. The Institution of Metallurgists. Lectures delivered at the Institution's Refresher Course 1952. (May, 1953), 156 pp., 15/6d each.

Organic Reactions. Vol. VII. Roger Adams, Editor in Chief. John Wiley & Sons, Inc., New York (1953), 440 pp. + V-VIII, $9.00.

Progress in Formaldehyde

Formaldehyde. J. Frederic Walker. ACS Monograph Series No. 120. Reinhold Publishing Co., New York (1953), XVI + 575 pp. $12.00.

Reviewed by Robert H. Barth, Research Department, Heyden Chemical Corp., Garfield, N. J.

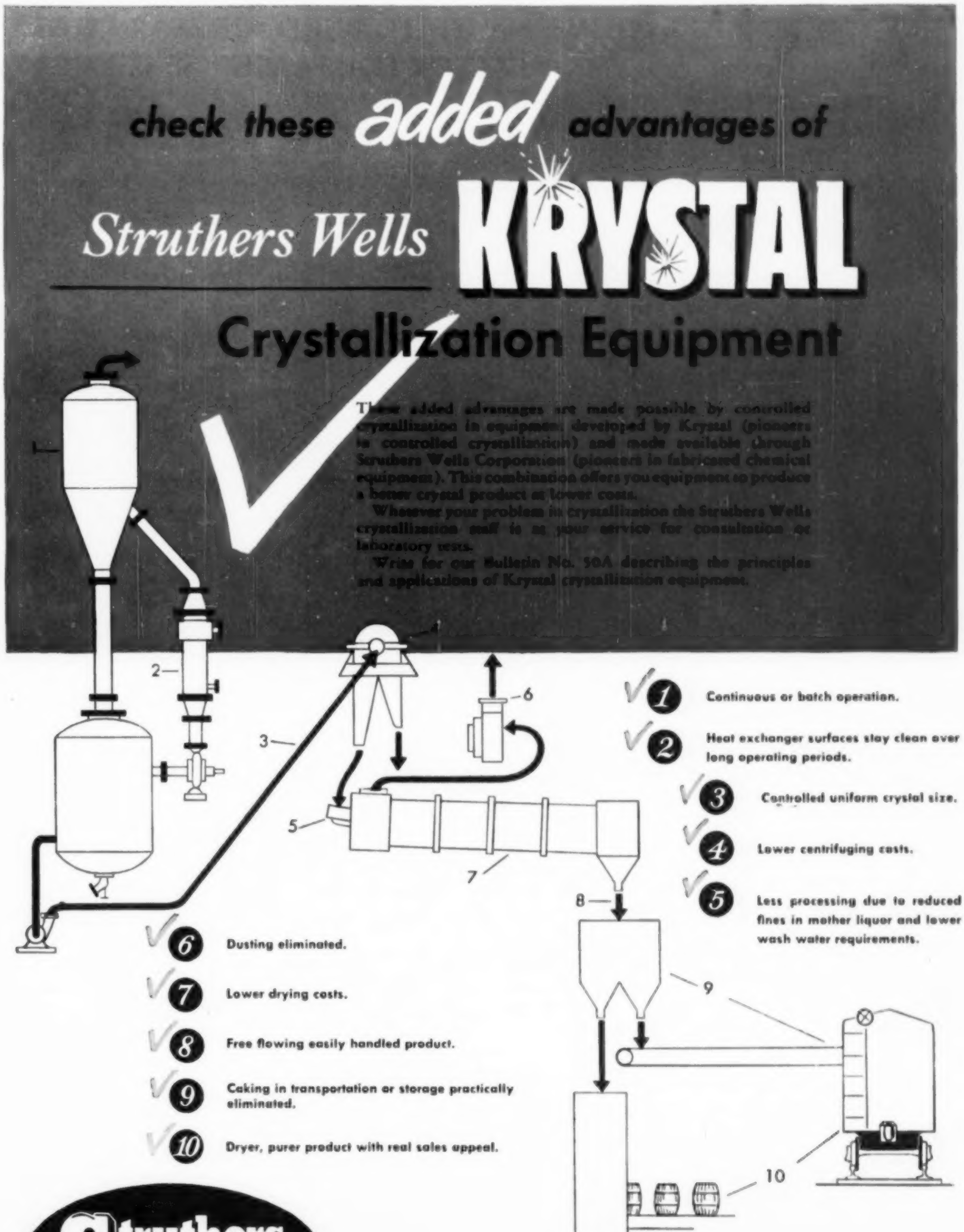
In the nine years since the first edition of this book appeared, the production of formaldehyde has doubled, and there has been the parallel progress in its technology.

J. Frederic Walker of the Du Pont Co. in the revised edition of his monograph has paid particular attention to these new developments in the preparation and uses of this chemical intermediate. His chapter on formaldehyde production, for example, contains, in addition to a review of the classical methods of formaldehyde manufacture, considerable information on recent advances in its preparation from methanol as well as a considerable discussion of its manufacture by the direct oxidation of methane and higher hydrocarbon gases.

By far the greatest part and value of this volume is the excellent review of the physical properties and chemical reactions of formaldehyde. Of this portion several chapters which have been expanded considerably are those on commercial formaldehyde solutions, physical properties of aqueous formaldehyde, formaldehyde polymers and the reactions of formaldehyde with amines, amides, and nitriles and hydrocarbons and hydrocarbon derivatives. In addition a chapter on the reactions of formaldehyde with heterocyclic compounds has been added.

Those engineers who are engaged in the manufacture or use of formaldehyde will be especially interested in the many tables of properties that have been included.

For the chemical engineer in the many industries that use formaldehyde, Dr. Walker's book will no doubt be an often-consulted, valuable reference volume.


check these added advantages of
Struthers Wells KRYSTAL
Crystallization Equipment
These added advantages are made possible by controlled crystallization in equipment developed by Krystal (pioneers in controlled crystallization) and made available through Struthers Wells Corporation (pioneers in fabricated chemical equipment). This combination offers you equipment to produce a better crystal product at lower costs.
Whatever your problem in crystallization the Struthers Wells crystallization staff is at your service for consultation or laboratory tests.
Write for our Bulletin No. 50A describing the principles and applications of Krystal crystallization equipment.
1 Continuous or batch operation.
2 Heat exchanger surfaces stay clean over long operating periods.
3 Controlled uniform crystal size.
4 Lower centrifuging costs.
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6 Dusting eliminated.
7 Lower drying costs.
8 Free flowing easily handled product.
9 Caking in transportation or storage practically eliminated.
10 Dryer, purer product with real sales appeal.
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STRUTHERS WELLS CORPORATION WARREN, PA.
Plants at WARREN, PA. and TITUSVILLE, PA.
OFFICES IN PRINCIPAL CITIES

GOVERNMENT TO BUILD NUCLEAR-POWER REACTOR FOR PEACETIME USE

In announcing last month the decision of the government to inaugurate the industrial use of nuclear energy by building a full-scale power reactor, Thomas E. Murray, United States Atomic Energy Commissioner, said at the Electric Companies Public Information Program in Chicago, "This is America's answer—its significant peacetime answer—to recent Soviet atomic weapons tests."

Having determined, said Mr. Murray, that private industry could not at this time "enter aggressively into the full-scale power reactor construction and testing stage" because of economic considerations, "the Commission has embarked on a program to construct a full-scale power reactor. It will produce a minimum of 60,000 kilowatts of electrical energy, with good possibilities of much higher output. We hope to have it in operation in three to four years. . . .

"There has been much talk," he continued, "and perhaps guarded criticism among some scientists and some industrial groups of the choice of the particular reactor design. . . . Let me assure you that it was not selected at random but is one of several studied for some time and approved by the entire reactor fraternity—and in addition, that this particular reactor was much farther along than any of the alternate systems. . . .

"There are still a number of competent scientists and engineers who believe we should have continued development efforts and only build a large-scale unit when we are more nearly sure that the power produced would compete in cost with conventional power. However, we recognized that such a course meant more paper studies and more delays. We decided, therefore, to 'launch out' into the reactor depths to construct a power producing unit designed according to the technology known now or within reasonable reach of the engineers' grasp. We were persuaded that we had much to learn that could only be learned by building and by operating. We knew that in all fields engineering goes forward much more rapidly and effectively if addressed to a known construction target. We recognize that costs of power, derived from this first reactor, will be higher than costs from modern plants. But we will really never know the answer to costs until we build and, still more important, until we operate several large-scale reactors . . . ."

In explaining why the Commission does not propose to build a dual-purpose reactor to produce both power and plutonium, which would permit the sale of the high-priced plutonium to offset some of the cost of the power, Mr. Murray said, "Today we are organized to take care of present weapons demand for plutonium from reactors either now in operation or nearing completion," and he quoted the Commission: "'It is the objective of this policy to further the development of nuclear plants which are economically independent of Government commitments to purchase weapons-grade plutonium.'"

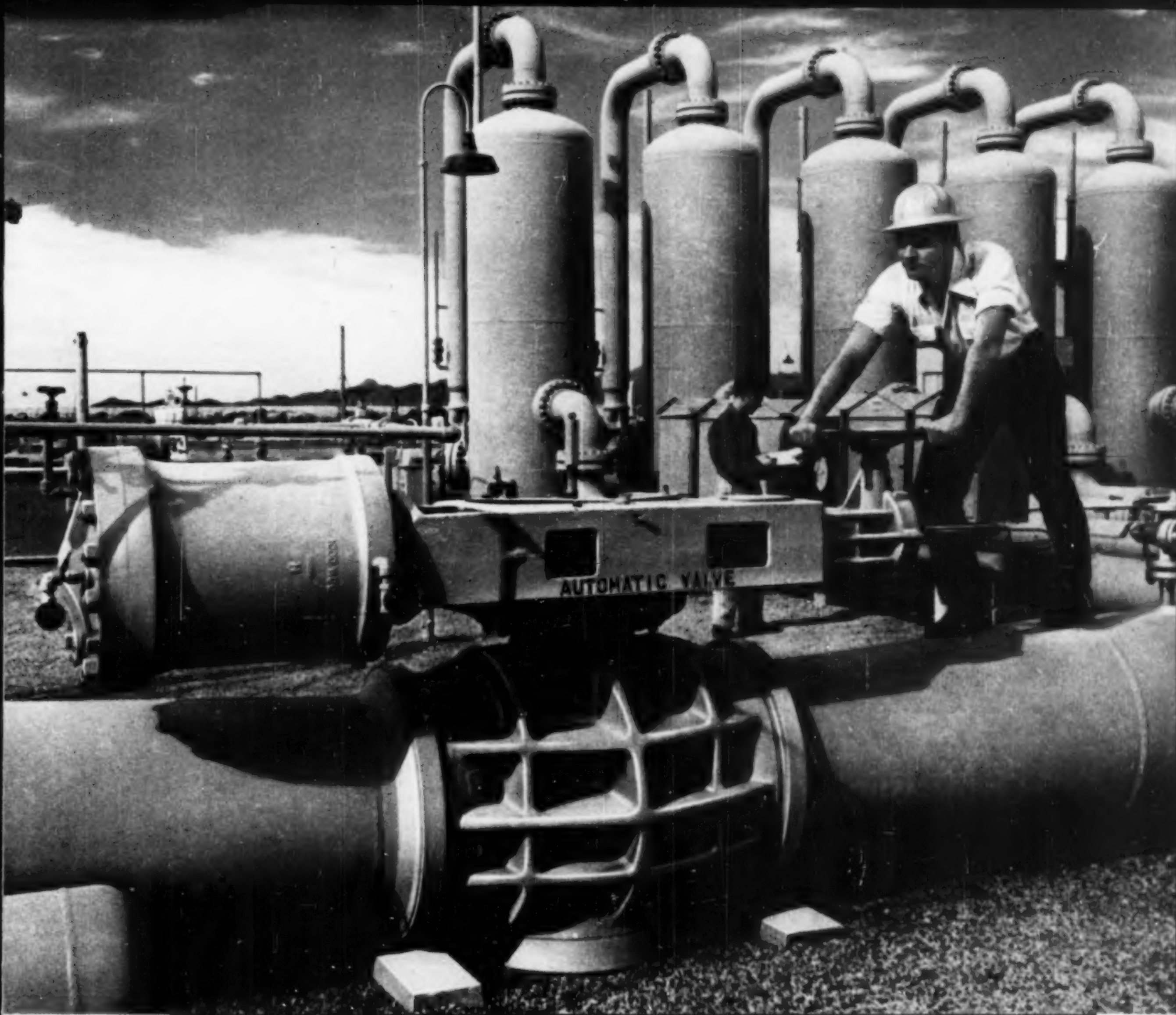
"It should also be kept in mind," Mr. Murray stressed, "that this first full-scale reactor will not, by any means, be the exclusive and sole effort of the Commission in the nuclear power field."

In alluding to the future of private industry in the field, Mr. Murray explained that "Just as I am convinced that initially the Federal Government must sponsor and finance full-scale power reactor development, so I am equally convinced that such sponsoring and financing will fall far short of what is needed unless there are enlisted in this cause the cost-cutting drives, the know-how, skills and competition of many segments of America's business and industry. . . . We are convinced that getting industry into the atomic energy program, on a privately financed basis, is essential to the attainment of our new urgent national goal—development of economic nuclear power."

In concluding his talk Mr. Murray cautioned, "We must be careful to avoid what might be called power myopia—the popular current assumption that peacetime atomic energy means only nuclear electric power. Remember how often, in the past, we have been smothered by the obvious. Even now we may be looking right at some uses for atomic energy of tremendous significance and not seeing them. I know of no better way of 'missing the boat' on these as yet unknown uses of atomic energy than to have government administrators or cost plus contractors alone dreaming them up."

Supervision of the new project has been delegated to the Reactor Development Division of the A.E.C. Immediate responsibility for the work has been assigned to Rear Admiral H. G. Rickover.

(More News on page 49)


AUTOMATIC VALVE

Lubricant makes a valve easier to operate, just as it will nearly any mechanical device. But that's far from its only function in a

NORDSTROM....

A system of internal grooves deposits a seal of lubricant, under pressure, around each port to prevent both internal and external leakage.

A NEW VALVE

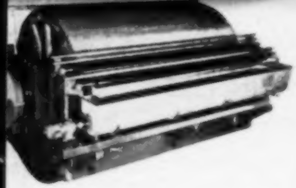
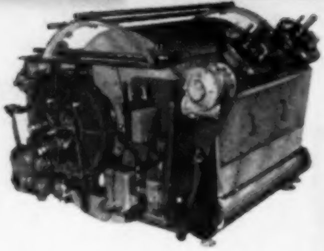
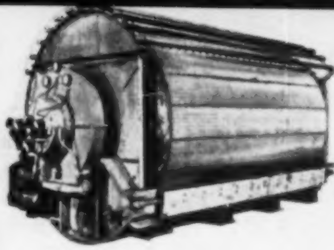
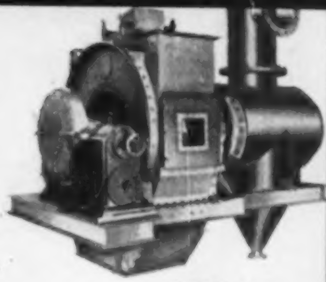
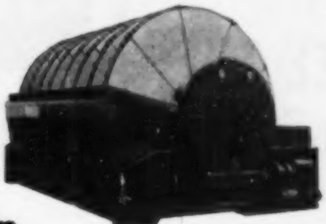
properly maintained, stays new for many years—always tight, always ready to operate in an emergency, because the lubricant in a Nordstrom valve keeps erosion-producing seepage from starting in the first place, filling the smallest scratch on the seating area with a film of plastic sealer.

EVERY TIME IT'S LUBRICATED

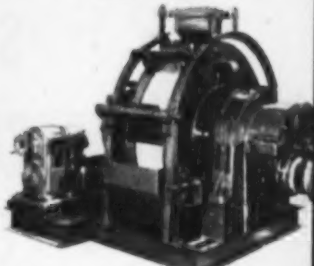
a Nordstrom valve is renewed—a new self-sealing seat around the valve ports. So, because they stay tight so much longer, Nordstrom valves, with systematic maintenance, actually lower operating costs.

Rockwell Manufacturing Company,
Pittsburgh 8, Pa.

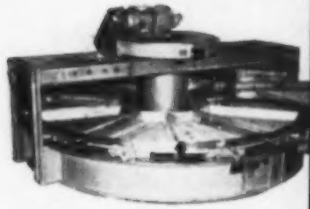
Nordstrom Valves Another Quality **ROCKWELL** Product

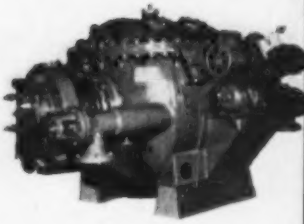
Expert Handling of Every Process Filtration Job Offered by Eimco



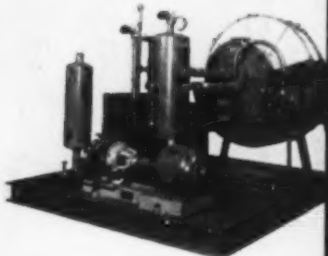
Illustrated here are some of the various types of continuous vacuum and pressure filters designed and built by Eimco Engineers.



From the smallest pilot plant filter station to the largest full production plant size filter, Eimco makes all types. We are prepared to test your product and recommend the model best suited to do your job and work efficiently in your flow sheet.



If yours is a simple dewatering job or a complicated selective hot acid separation process there is an Eimco filter that will do the job better, cheaper and faster.



Let engineers, with the experience of Eimco design and operating men behind them, help solve your filtration problems. Write today.

EIMCO A483

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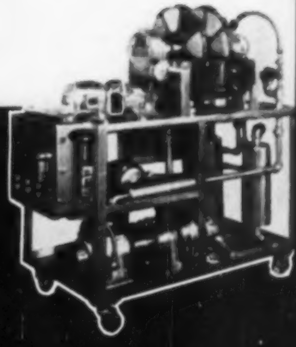


AWARD WINNERS

(Continued from page 34)

(1950) and "Pressure Drops for High Vacuum Flow of Air through Annular Sections," with C. R. Alancraig (1952).

Mr. Bromley at present is teaching at the University of California, from which he received his B.S. and Ph.D. degrees. After he completed his work for the master's degree in chemical engineering at Illinois Institute of Technology, he returned to California to work on the Manhattan District Project at the University of California Radiation Laboratory. In 1946, when the chemical engineering group was formed at California, he was appointed an instructor at the university and in 1952 became associate professor.

Dr. Bromley's technical writings have been mainly in the fields of heat transfer, high temperature, thermodynamics, and high vacuum; he has been author or co-author of more than thirty-six papers.

Aside from his writing and teaching, Dr. Bromley has also served as consultant for the Matmor Canning Company and the U. S. Naval Radiological Defense Laboratories and U. S. Atomic Energy Commission Radiation Laboratory.

He is a member of the American Association of University Professors, the American Chemical Society, Sigma Xi, Tau Beta Pi, Phi Lambda Upsilon, and Alpha Chi Sigma.

A. McLaren White Award

The Student Contest problem this year concerned debottlenecking existing equipment, and the judges commented that "each solution had a number of features recommending it for consideration." Raymond M. Cartier, winner of the first prize of $200—the A. McLaren White Award, given in honor of a young chemical engineer—graduated last June with a B.Ch.E. summa cum laude from the Polytechnic Institute of Brooklyn. During the summer he worked at the Micarta Plastics division of Westinghouse Electric Co. and is at present working toward his master's degree at Brooklyn Polytechnic on a Westinghouse Fellowship. He is specializing in nuclear technology.

The second prize of $100 was awarded to Donald W. Sundstrom, who at present is a graduate assistant in the chemical engineering department of Worcester Polytechnic Institute.

Shmuel Dankner, who graduated from the University of California, won the third prize of $50.

Honorable Mention went to Robert L. Kendig of Oklahoma A. & M. College, Vladimir L. Stoikov of the University of Illinois, and Robert W. Scher of Purdue University.

DOWTHERM . . . THE HEATING MEDIUM THAT ALSO COOLS

Developed by DOW, this modern heat transfer medium makes alternate heating and cooling possible in the same equipment!

Highly efficient Dowtherm®, used as a vapor for accurate high temperature process heating, may be utilized as a liquid when your processing cycle calls for alternate heating and cooling in the same equipment. This provides a versatile system in which a series of accurately controlled temperatures is possible without transferring the material being processed. Dowtherm, as a liquid coolant, is particularly valuable in reactions where it is necessary to absorb heat at high temperatures.

If your process calls only for heating, a Dowtherm vapor system will provide up to 750°F. heat, precision controlled by simple pressure regulation. Since Dowtherm does not contain any minerals, there are no costly scaling problems in your vaporizer or processing equipment . . . only a minimum of routine maintenance is required.

Dowtherm was created by the Dow research team for the chemical, petroleum, paint, food and other process industries—has helped to increase production and even made possible new products. To learn how you can gain these benefits write to THE DOW CHEMICAL COMPANY, Midland, Michigan, *Dept. DO 3-7 B.*

you can depend on DOW CHEMICALS

Lapp PULSAFEEDER

PISTON-DIAPHRAGM CONTROLLED-VOLUME PUMP

Not competitive with any pump of more conventional design, the Lapp Pulsafeeder is a highly specialized, precision, custom-built machine suited to a wide variety of special applications involving controlled-volume pumping of fluids.

Basic feature of Lapp Pulsafeeder design is its combination of reciprocating piston action (to provide the accuracy of positive displacement) with a hydraulically balanced diaphragm which isolates material being pumped from working pump parts—and, of course, eliminates need for stuffing box or running seal.

Control of pumping rate is achieved at constant pumping speed; variable flow results from variation in piston stroke length—adjustable by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

Justification for this specialized premium construction is evident in the many, and varied, applications in which Lapp Pulsafeeder alone is able to perform satisfactorily. In fact, the economies of continuous processing, automatic proportioning, feeding and filling in many operations are possible only because of the unusual characteristics of Lapp Pulsafeeder.

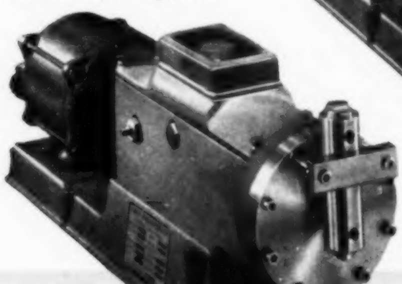
In general, use of the Lapp Pulsafeeder is indicated for continuous (or intermittent) pumping, at accurately controlled volume, of fluids which cannot be safely exposed to conventional pistons, cylinders and stuffing box packing—because of the corrosive action of chemicals being handled and/or need for protection of product against contamination.

To meet the varied demands of low-viscosity liquids, high-viscosity liquids, slurries and gases, liquid-handling heads and valves are offered in a variety of materials and designs, four of which are shown below.

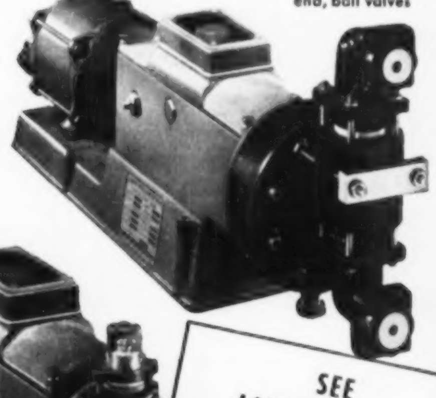
Lapp Auto-Pneumatic Pulsafeeder—responds to pneumatic instruments

WRITE for Lapp Bulletin 300, which shows typical Pulsafeeder applications and flow charts, and which describes and lists specifications of models over a wide range of capacities and constructions. Lapp Insulator Co., Inc., 170 Wendell St., Le Roy, N. Y.

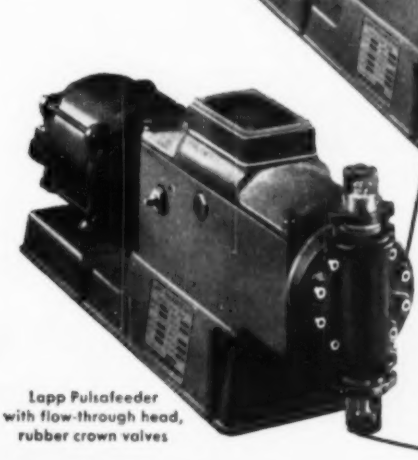
Lapp Pulsafeeder with flow-through head, ball valves



Lapp Pulsafeeder with outboard cone valves



Lapp Pulsafeeder with non-metallic liquid end, ball valves



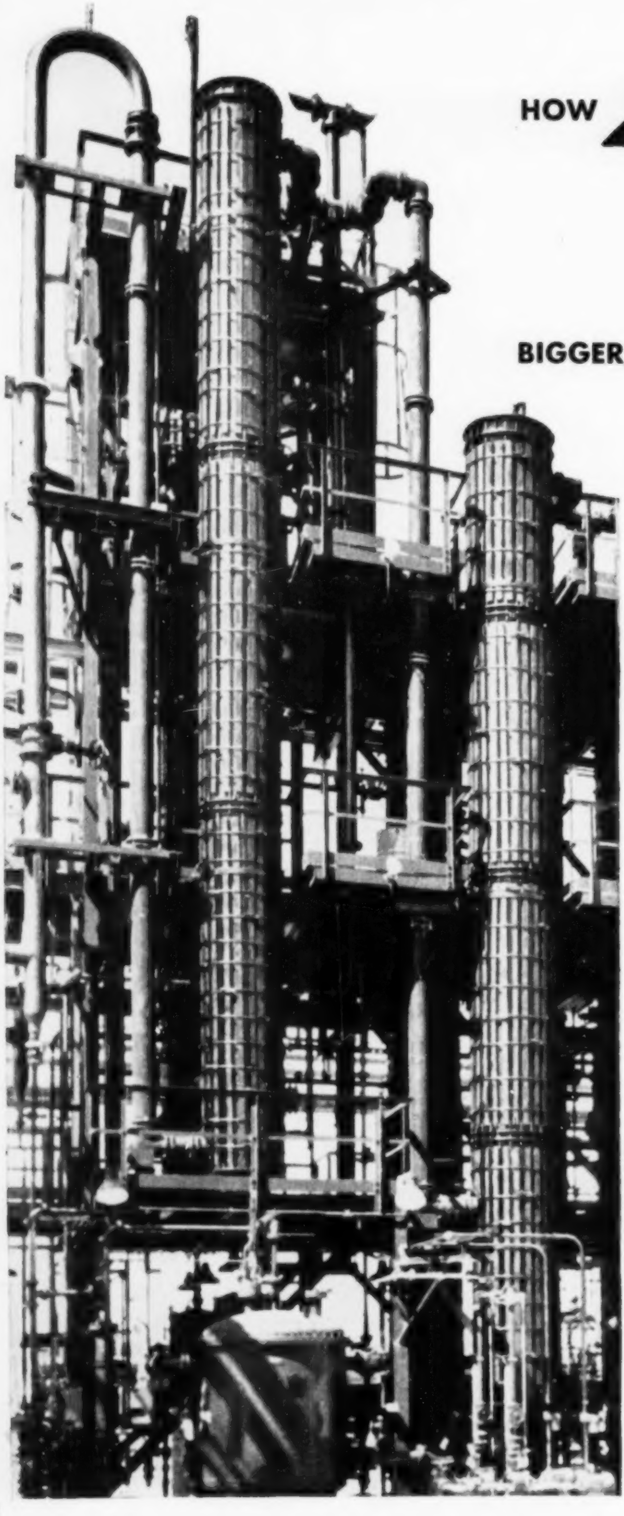
Lapp Pulsafeeder with flow-through head, rubber crown valves

Lapp PROCESS EQUIPMENT

SEE LAPP PORCELAIN AND PULSAFEEDERS

BOOTH 814

CHEMICAL SHOW PHILADELPHIA NOV. 30—DEC. 5



NEWS

(Continued from page 44)

REVISED ENGINEERING COURSE ADVOCATED

The immediate necessity for revising engineering education stems in large part from the fact that engineers have become responsible for the continuity of research in all fields of engineering science, according to L. E. Grinter, dean of the graduate school, University of Florida, who spoke before the joint meeting of the Engineers Council for Professional Development and the American Society for Engineering Education held at the Statler Hotel, New York, from October 14 to 17.

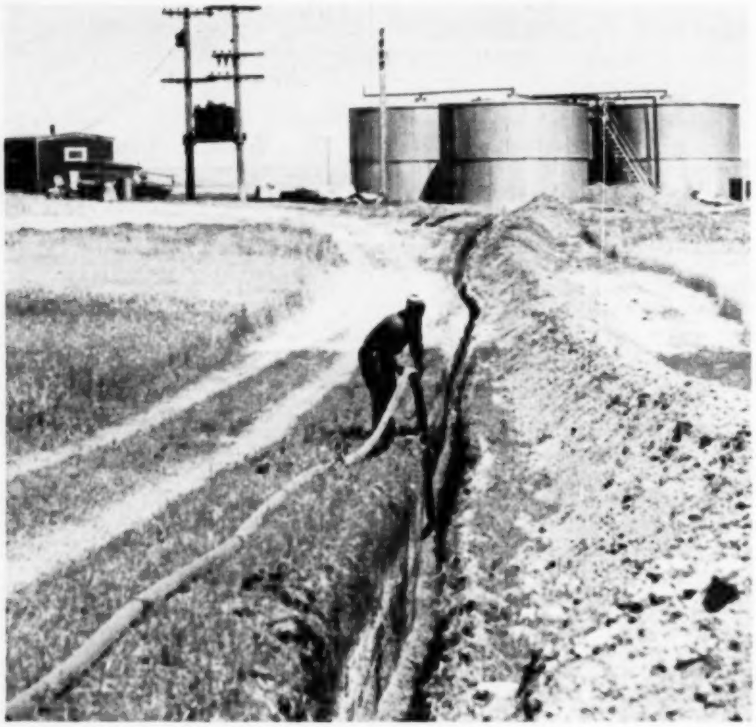
In the last ten years, Dean Grinter pointed out, nuclear problems have occupied an increasing number of research physicists. "It seems doubtful," he said, "if the interests of these physicists will ever be returned in sufficient measure to influence greatly research in vibrations, elasticity, heat transfer, and the other engineering sciences."

Cornelius Wandmacher, professor of civil engineering at the University of Cincinnati, described the cooperative program of post-college training experimented with in Cincinnati. Sponsored by nine of the city's industries, twenty-three local sections of national technical and scientific societies, and members of the university administrative staff, the program embraces orientation and training in industry, continued education, integration into the community, professional registration, self-appraisal, and recommended reading.

At an all-day meeting sponsored by the Engineering College Research Council and the Engineering College Administrative Council, the theme of creativity was considered from the point of view of arts, industry and engineering.

At a meeting of the Engineers Council for Professional Development during the joint session the following officers were elected for 1953-54: Chairman, L. F. Grant, Engineering Institute of Canada; vice-chairman, M. D. Hooven, Public Service Electric and Gas Co.; secretary, Nelson Hibshman, assistant secretary, A.I.E.E.; and assistant secretary, S. L. Tyler, secretary, A.I.Ch.E. Members of the executive committee, in addition to the officers, are H. S. Rogers, Brooklyn Polytechnic Institute; C. E. Lawall, Chesapeake and Ohio R. R. Co.; Guy R. Cowing, General Motors Institute; E. V. Buchanan, consulting engineer, London, Ontario; Thorndike Saville, New York University; Warren McCabe, Brooklyn Polytechnic Institute, and R. G. Warner, United Illuminating Co., New Haven, Conn.

PLASTIC PIPE LINE TRANSPORTING CRUDE OIL



The first cross-country pipe line to be made entirely of plastic is now delivering crude oil for a distance of nine miles in Montana, according to an announcement by Eastman Chemical Products, Inc. The pipe, 3-in. I.D. with a wall thickness of 0.125 in., was produced of Tenite butyrate plastic by the extrusion process. It is designed to operate at a maximum pressure of 90 lb./sq.in. at 60° F. and to deliver 2,500 bbl. a day. Being inherently corrosion resistant, the pipe, according to company engineers, will outlast steel pipe, and will also be free of the paraffin accumulation that plagues steel pipe. A 20-ft. section of the pipe weighs 13 lb. and can be laid by one man. The pipe line is owned by Plastic Service Lines, Inc., Denver, Colo.

As shown above, the pipe is flexible when joined in a continuous length and therefore conforms to curved sections of the ditch without the use of elbows.

TEACH-THE-TEACHER PROGRAM IN CINCINNATI

Another in the series of "Industry-Teaches-the-Teacher" programs sponsored by the Chemical Engineering Education Projects Committee of A.I.Ch.E. was held on November seventh at the Vulcan Copper and Supply Co., Cincinnati, according to an announcement by William Licht, acting head, department of chemical engineering, University of Cincinnati. About thirty chemical engineering instructors and professors in the region attended the all-day session, at which staff members of the Vulcan Engineering Division of the company discussed theoretical concepts, azeotropic distillation systems, extractive distillation systems, and project engineering of tower accessories.

BUBBLE-FORMATION FILM

"Bubble Formation," a 16-mm. color sound movie showing high-speed pictures of air bubbling through holes into various liquids, has been released recently by the Du Pont Co. Prepared to encourage research on the fundamentals of gas-liquid contacting, the film will be shown at the Distillation Symposium at the St. Louis Meeting and will be on loan to educational institutions and other interested groups. Requests should be addressed to the Engineering Research Laboratory, E. I. du Pont de Nemours and Company, Wilmington 98, Delaware.

CHEMICAL ENGINEERING GRANT TO ROSE INST.

Rose Polytechnic Institute, Terre Haute, Ind., has received the Frederick Gardner Cottrell grant of $2,680 from the Research Corp. in support of a project to investigate the effect of fluid physical properties on heat transfer to boiling binary liquid mixtures. S. G. Bankoff, head of the department of chemical engineering, will be in charge of the project.

(More News on page 52)

NEWS

(*Continued from page 50*)

NEW GENERAL MANAGER FOR A. E. C.

The appointment of Major General K. D. Nichols, wartime district engineer for the Manhattan District, as successor to Marion W. Boyer as general manager for the Atomic Energy Commission was announced to take effect on November 1. General Nichols, who was Chief of Research and Development, U. S. Army, retired from military service upon assuming his new duties.

Originally interested in hydraulic engineering, General Nichols was selected for assignment to a special Corps of Engineers organization set up in 1942 on order of President Roosevelt for developing and producing the atomic bomb. He supervised the research and development connected with the establishment of plants for the production of plutonium and uranium-235, including the construction of Oak Ridge, Tenn., and Richland, Wash. When the responsibility for atomic energy was turned over to the A.E.C. in 1947, General Nichols became a professor of mechanics at West Point but soon returned to atomic-energy work, first as a consultant and later as Chief of Research and Development, U. S. Army, and Deputy Director of Guided Missiles.

FEDERAL RESEARCH EXPENDITURES DOWN

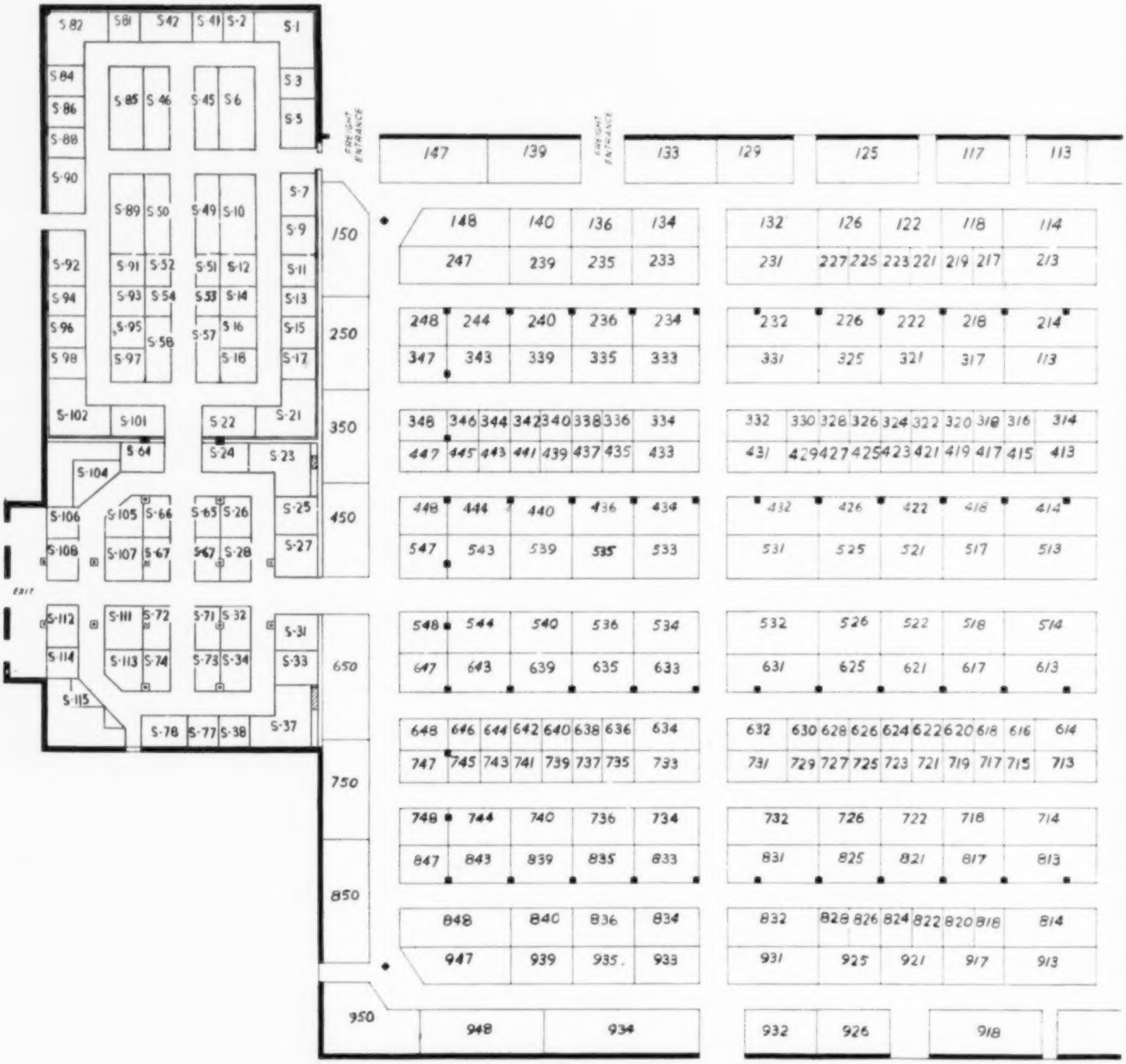
Both obligations and expenditures of Federal agencies for scientific research and development are expected to drop in the fiscal year 1954, according to estimates compiled by the National Science Foundation. Estimates of obligations are $2,074 million for 1954, compared with $2,187 million for 1953; expenditures are estimated at $2,187 million in 1954 and $2,205 million in 1953. The lag between obligations and expenditures has averaged about nine months over the past several years, and the decline in obligations for 1954 will therefore presumably be reflected in a further decrease in expenditures in 1955, according to the Foundation.

Estimates of the Department of Defense constitute the largest portion of the totals for both obligations and expenditures, and the Atomic Energy Commission ranks next. Present figures, based on appropriations approved by the 83 Congress, first session, are $1,556 million in obligations for 1954 and $1,636 for expenditures for the Department of Defense and $239 million for obligations and $266 million for expenditures for the A.E.C. These estimates are still tentative as several agencies plan revisions in their programs.

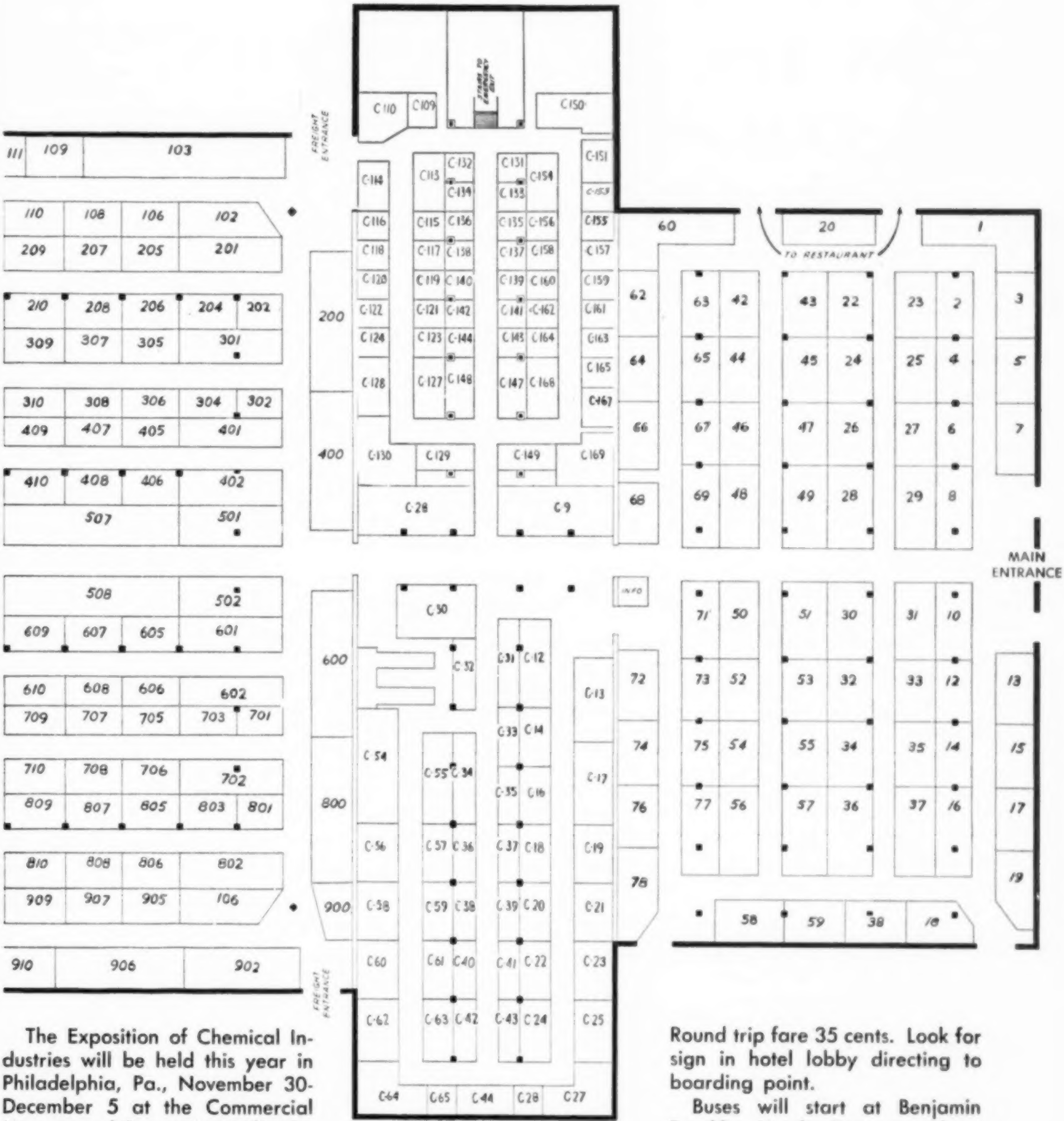
24th

EXPOSITION

of chemical industries
commercial museum and convention hall
philadelphia, pennsylvania
november 30 **december** 5



FLOOR PLANS OF COMMERCIAL MUSEUM AND CONVENTION HALL



The Exposition of Chemical Industries will be held this year in Philadelphia, Pa., November 30-December 5 at the Commercial Museum and Convention Hall. The doors will open Monday, November 30, at 2 P.M., then daily at 11 A.M. The Show will close at 10 P.M., except Wed. and Sat. when it will close at 6 P.M.

The Museum is at 34th Street and Curie Avenue.

SPECIAL BUS SERVICE

As a convenience for those attending the Exposition special bus service will be provided. Buses will leave principal hotels at frequent intervals for Commercial Museum and Convention Hall. Round trip fare 35 cents. Look for sign in hotel lobby directing to boarding point.

Buses will start at Benjamin Franklin Hotel. First run about 10:15 or 10:30 A.M. and thereafter about 10 minutes or one-half hour apart depending upon need.

Also, transportation by street cars Nos. 13 and 42 along Walnut Street to 34th Street. Then walk 1 block to Curie Avenue.

DO YOU WANT INFORMATION ON THE SHOW EXHIBITS?

Let "C. E. P." Data Service Get It for You

Use Postage Free Cards on Page 60

On the following pages are descriptions of many of the exposition displays. The story is brief—but descriptive—written from information supplied by the exhibitor. Perhaps you want to know more—if so circle the appropriate number on the post card on page 60 and detach and mail, no postage required. We will forward your requests to the manufacturer and the data will come to you directly from him. In this easy manner you may bring to your desk the descriptions of new equipment, new chemicals, valves, motors, materials of construction, etc., that will be shown at the 24th Exposition of Chemical Industries. Then too, the same post card may be used to bring to you information about every product advertised in this month's issue of "C.E.P." Use this free, up-to-date service this month and every month to keep yourself informed on the latest and best in the process industries.

1 • **DISTILLATION EQUIPMENT.** Distillation equipment featured as fully automatic, & achieving quality control through continual recording of distillate purity & diversion of substandard distillate. Also an all-welded laboratory autoclave. Aetna Scientific Co. Booth C-28.

2 • **PROCESSING EQUIPMENT.** Display of pumps designed for liquids to 500° F.; an enclosed tube-cooled motor; a 5 by 12 ft. Rip-Flo vibrating screen with heating unit; an all-metal circle sifter; & a cross-sectional model of a crusher. Allis-Chalmers Mfg. Co. Booth 508.

3 • **MICROANALYSIS.** Three new instruments —a micromanipulator, a micro-forge, & an electroanalyzer. Also new electronic instruments will be shown with their standard line. Aloe Scientific Division. Booth 53.

4 • **LABORATORY EQUIPMENT.** Laboratory tools and instruments such as high pressure pumps, valves, fittings, climate labs, heaters, relays, regulators will be shown by American Instrument Co., Inc. Booth 736.

5 • **FILTERS & CENTRIFUGALS.** Exhibit will include from Niagara Filters Division a horizontal filter for liquid clarifications in which recovery of solids is an important factor. Combines high clarity & rapid cleanout of semidry solids. From Tolhurst Centrifugals Division a new continuous centrifugal. Also a 12-in. laboratory model & 26 in. V-belt driven center-slung centrifugal with fume-tight cover, & other models. American Machine and Metals, Inc. Booths 802-806-808.

6 • **CONTROL INSTRUMENTS.** A rapid scanning spectrophotometer & a desk-type metallograph. Spectrophotometer combines optical unit & electrical indicating device which traces curves, 60/sec. on face of cathode-ray tube against linear wavelength. Metallograph permits operator to perform all functions from sitting position. American Optical Co. Booth 348.

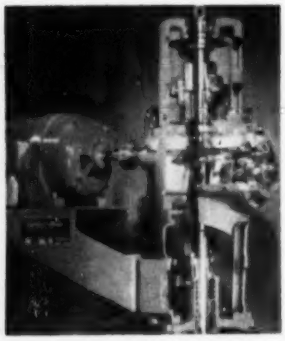
7 • **STILLS & STERILIZERS.** Water stills for applications requiring distillate of low-mineral content or free from pyrogens. Also on display, cylindrical models of steam & carboxide sterilizers. American Sterilizer Co. Booth 732.

8 • **DUST COLLECTOR.** Cut-away model of full-sized Dustube cloth-filter-type dust collector having 1,370 sq.ft. of filter cloth. Wide size range for processing operations, including carbon black, fertilizer, pharmaceuticals, paint, & food. American Wheelbrator & Equipment Corp. Booth 133.

9 • **STEAM TRAPS & PURIFIERS.** Steam traps & purifiers for process operations. Purifier removes dirt & moisture automatically. Inverted bucket steam traps newly designed for easy installation, maintenance & inspection. V. D. Anderson Co. Booth C-129.

10 • **FILTER MATERIALS.** Filter papers & cellulose powders for chromatography & electrophoresis. Other materials on view will be industrial filter papers for plate & frame filters & filtering machines. H. Reeves Angel & Co., Inc. Booth 344.

11 • **SOLVENT RECOVERY.** Solvent-recovery system features continuous, combined evaporator-stripper. Separates components of two-



Lightnin Mixer of Mixing Equipment Co.

Trenntechnik centrifugal separator and screen displayed by Merco Centrifugal Co.

phase systems. Design features of unit as well as other process equipment will be photographically displayed. Artisan Metal Products, Inc. Booth 320.

12 • CORROSION-PROOF CEMENTS — PLASTICS. Corrosion-resistant cement Alkor 5E for alkali, nonoxidizing acids, oils, greases, etc. at temperatures to 350° F. Also rigid polyvinyl & polyester glass cloth constructions such as tanks, ductwork. Atlas Mineral Products Co. Booth 429.

14 • HIGH PRESSURE EQUIPMENT. Hofer high pressure gas compressor for 5,000 atm. Horizontal multistage construction. New design production size high pressure valves for use in producing ammonia & polyethylene. Valves & fittings for pressures to 100,000 lb./sq.in Autoclave Engineers, Inc. Booth 434.

15 • SOLENOID VALVES. Three-way solenoid valves, corrosion resistant to gases & liquids. Stainless & carbon steel. Used as pilot control of diaphragms & applying & exhausting pressure from single- or double-acting cylinders; direct control in chemical process applications or to divert & select flows from one of two pipe lines. Watertight or explosion-proof solenoid. Automatic Switch Co. Booth C-116.

16 • MIXERS. Display of mixing machinery including Ko-Kneader, & continuous centrifugal with auxiliary dryer. Ko-Kneader is continuous mixing & kneading machine for mixing dry, semiplastic, and plastic masses. Centrifuge also washes & dries crystalline products for shipment. Baker Perkins Inc. Booth 540-544.

17 • DEMINERALIZING EQUIPMENT. Water stills, water demineralizers, & purity meter. One demineralizer will be mixed bed, with simplified regenerating. Display unit 50 gal./hr. with Lucite column for observation of resin action. Also Ventgard, protective device for water-storage tanks which removes matter, bacteria, acid & alkali gases from air before entrance into tank. Barnstead Still & Sterilizer Co. Booth 636.

18 • LECTRO-CLAD PIPE. A nickel-lined steel pipe, Lectro-Clad. Also steel sheet having uniformly thick deposit of nickel, electroplated over entire surface; selenium rectifiers for use in chemical industry; use of precious metals and chemical processes. Bart Mfg. Corp. Booth S-22.

▲
Use this service to bring to your desk the literature which you fail to see or get while at the chemical show.

19 • LABORATORY EQUIPMENT. Gas-fired laboratory size continuous rotary dryer & continuous indirect heat calciner. Units complete with drive, controls, feed & discharge hoppers, etc., exact replicas of plant equipment. Aids process engineers in determining rate of feed, time cycle, etc. C. O. Bartlett & Snow Co. Booth 209.

20 • PROCESS PUMPS. Working cutaway exhibits of high-pressure reciprocating pumps supplied with sectionalized fluid end & all-enclosed drive. Operation illustrates inside- & outside-packed operation. For use in chemical process industry. Various installations & power unit mounts, including variable capacity arrangement. John Bean Division, Food Machinery and Chemical Corp. Booth 322.

21 • COMPLEXING AGENTS. Amino-acid-type complexing agents, trade-named The Versenes. For control of metallic ion contamination in products & processes by forming stable, water soluble complex compounds. Also new agents which chellate iron strongly over wide pH ranges. Versene iron chelate used in combating iron chlorosis in citrus and allied fields. Bersworth Chemical Co. Booth 813.

22 • CORROSION-RESISTANT MATERIALS. Materials of platinum & the platinum group; stainless steel tubing, Monel, K-Monel, A-nickel in sizes .008 to 1 in. O.D. Other fabricated tubular specialties. J. Bishop & Co. Platinum Works Booth 809.

23 • MIXER-KNEADER. Beken duplex mixer-disperser kneader & the Planetex vertical mixer. Mixer-dispenser for homogeneous batches regardless of proportions & ingredients. Vertical mixer uses Beken intermeshing paddle principle & rotating planetary action. Bramley Machinery Corp. Booths 723-725.

24 • CONTROL INSTRUMENTS. Instruments for indicating, recording, controlling and proportioning rate of flow for chemical process applications. Included are rotameters, purge meters, glass laboratory meters, etc. Also new additions to line; flow handbook, flow-mizer, armored rotameter. Brooks Rotameter Co. Booth 210.

25 • GAS CATALYSIS. Combination dissolved oxygen & hydrogen analyzer for continuous & simultaneous recording of oxygen dissolved in boiler feed water & free hydrogen in steam condensate. Also combination oxygen, carbon dioxide & combustibles analyzer on kiln gas. Single & multi-point pH recorders; pyrometers; moisture indicators; gas testers, etc. Cambridge Instrument Co., Inc. Booth 926.

26 • DIFFUSION PUMP. Supervac high-speed oil diffusion pump quickly dismantled for easy cleaning. Also high-vacuum backing pump & complete line of metal couplings & connectors. New Kool-Grip Kjeldahl flask featuring a protecting cemented layer of cork. Central Scientific Co. Booth 606.

27 • DE-SLUDGING CENTRIFUGE. Automatic desludging with new centrifugal separators. Eliminates valves via automatic opening & closing bowl permitting continuous discharge of drier sludge. Preset timing device controls desludging. Centrico, Inc. Booth 2.

28 • FERTILIZER PLANT. A working model of a fertilizer plant, employing carbonitric process, plus a high pressure ammonia oxidation unit. Fertilizer plant capable of producing complex fertilizer in any desired ratio to 40 units of plant food. Chemical and Industrial Corp. Booth S-7.

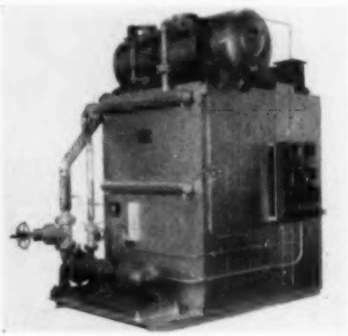
29 • SNUBBERS & TRAPS. A display of pressure snubbers, mercury traps, filters & pipetting machines. Pressure snubbers are simple devices for dampening line surges, Mercury traps prevent mercury loss from manometers owing to surging. Chemiquip Corp. Booth S-53.

30 • FLOATING TANK ROOF. Working model of Horton doubledeck floating roof for storage tanks. Reduces evaporation, corrosion, eliminates fire hazard & prevents oxidation of stored product. Also working model of Horton Vaporsphere to reduce evaporation loss from tanks of hydrocarbons, commercial solvents, etc. Chicago Bridge & Iron Co. Booth 807.

31 • SWIVEL JOINTS. Ball-bearing swivel joints providing 360° rotation in three planes. Five hundred types, available for pressures and services from 28 in. vacuum to 20,000 lb./sq.in. & temperatures to 500° F. To conduct fluid or gas through flexible lines, including loading racks, manifolding lines, vibration & pulsation lines & aluminum marine suction & discharge hose. Chicksan Co. Booth 607.

32 • POLYVINYL PIPE & FITTINGS. A display of nonplasticized polyvinyl chloride pipe and fittings. Pipe ½ through 6 in. diam. Molded fittings ½- through 2-in. diam. Above 2-in. fittings are flange type. Also air ducts, tanks,

(Continued on page 62A.
Use postcard on page 59)



Forced-recirculation high-temperature generator of International-LaMont.

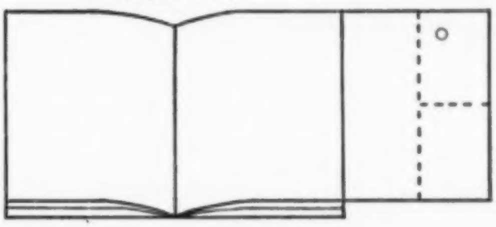
Consolidated Engineering Co. mass spectrometer for monitor and control of continuous processes.

PRESERVE OUR HERITAGE: FAITH, FREEDOM AND INCENTIVE

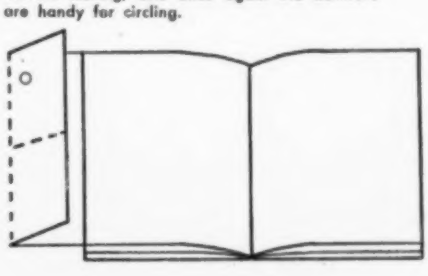
for your information

This "C.E.P." information service is a convenient way to get the chemical engineering information you need on new equipment, on advertised products, on the newly announced developments reported on these pages. A one post card inquiry designed to bring data quickly and easily. Circle the items of interest, sign your name, position, address, etc., and drop in the mail.

Just a moment is needed to learn how to use this insert. When looking through the front part of the magazine pull the folded portion of the insert out to the right, and the numbers on the post card are convenient for marking. THEN . . . .



as you pass the pull-out page, and it is on the left, fold the post card back along the vertical scoring, and once again the numbers are handy for circling.



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PRODUCTS

IFC • SOLVENT RECOVERY PLANT. Activated Carbon plants used in plastics, rubber, synthetic fibers, smokeless powder, rotogravure printing, lacquer coating, and other industries. Booklet.
Carbide & Carbon Chemicals Co.

3R • DRAVER FEEDERS. To regulate the flow of materials to sifters, dryers, elevators, grinders and other production units. Also for proportioning and mixing of dry powdered, granular or flake materials.
B. F. Gump Co.

4L • COLLINS HELIUM CRYOSTAT. For liquefying helium. Maintains a test chamber from normal room temperature to within two degrees of absolute zero.
Arthur D. Little, Inc.

5A • STAINLESS STEEL PROCESSING TANKS. Custom fabrication of tanks and pressure vessels. Steel and alloy plate fabricators and erectors.
Nooter Corporation

6A • STEEL VALVES. Features lube oil plant, using Crane steel valves on lines to concentrated sulphuric acid storage and blow cases.
Crane Company

7A • BALL BEARING SWIVEL FITTINGS. For transfer of liquid or semi-solid chemicals, oil, gas, air, steam, etc.
Emsco Manufacturing Co.

8L • GAGES AND VALVES. Specialized gages, valves and other equipment to meet problems in the observation of liquids and levels.
Jerguson Gage & Valve Co.

9A • SINTERED METALLIC OXIDES. A series of blended, formed and sintered metallic oxides, called Alite. May offer unusual advantages to the design engineer.
U. S. Stoneware Co.

10A • HONEYWELL INSTRUMENTATION. Cabinet dryers are controlled by panel of wet and dry bulb Brown thermometers. Composite Catalog.
Minneapolis-Honeywell Regulator Co.

12A • CELITE FILTRATION. To purify water for re-use. Comes in nine standard grades for many industrial uses.
Johns-Manville

13A • PROCESS COOLING. Engineers specializing in the techniques of process cooling. Publications.
The Marley Co.

14A • AUTOMATIC INSTRUMENTATION. Stabilog Controllers hold process variables within critical latitudes.
The Foxboro Co.

15R • PLUG VALVES. Adjusting nut permits the plug to be lifted slightly from its seat for easy opening and closing.
Hamer Oil Tool Co.

16A • GLASSED STEEL REACTOR. Complete line of glassed steel columns, heat exchangers, valves, fittings, condensers and accessories.
The Pfaudler Co.

568A • TURBO-MIXERS. Examples of hydrogenators, flotation conditioners, flotation cells, causticizing operations, anti-biotics fermentation, aerators and floaters, and resin cooker.
Turbo-Mixer Div., General American Transportation Corp.

25A • WIGGINS GASHOLDERS. 100% dry seal gasholder (no water, no tar, no grease). Old gasholder can be converted to a Wiggins type.
Wiggins Gasholder Div., General American Transportation Corp.

27A • FILTERS. For liquid clarification and solids recovery. Sizes handling up to 30,000 gal./hr. and flow rates up to 45,000 gal./hr.
Niagara Filters Div., American Machine and Metals, Inc.

28A • VERTICAL TURBINE PUMPS. Example shows pumps on a cooling tower in a Los Angeles soap factory. Bulletin.
Johnston Pump Co.

29A • PRESSURE VESSELS. Elevated tanks, horizontal tanks, stacks, pressure vessels, pipe, and digesters.
Posey Iron Works, Inc.

31A • STEAM-POWERED COMPRESSORS. Balanced piston-valve riding cut-off steam end, double-crosshead and tie-rod construction, and channel compressor valves.
Ingersoll-Rand

32A • "KARBATE" EQUIPMENT. Heat exchangers, cascade coolers, centrifugal pumps, HCL absorbers, pipe and fittings.
National Carbon Co.

35A • ACETYLENE PROCESS. Acetylene produced by Wulff Process. Girdler designs, processes and builds plants, and manufactures processing apparatus.
The Girdler Co.

36A • AMBERLITE CATION AND ANION EXCHANGERS. For processing glycerine, sorbitol, sugar, syrups, arabic acid, formic acid, acetone, formaldehyde, metals, and milk.
Rohm & Haas Co.

37A • HEAVY DUTY FILTER. 60 sec. opening or closing without disconnecting piping. Available in sizes from 100 to 2000 sq. ft. filtering area.
Sparkler Manufacturing Co.

39A • CRYSTALLIZATION EQUIPMENT. Fabricated chemical equipment for controlled crystallization.
Struthers Wells Corp.

40L • OIL RECLAIMER. Equipment for reclaiming, filtering, purifying and re-refining oil. Bulletin.
The Hilliard Corp.

41A • NORDSTROM POWER OPERATED VALVES. Operates on a quarter turn. Can be equipped for electric, hydraulic or pneumatic operation, with automatic, manual or remote control. Also valve lubricants.
Rockwell Manufacturing Co.

43A • PROCESS FILTRATION. Various types of continuous vacuum and pressure filters. From pilot plant size filter station to largest full production plant size.
The Eimco Corp.

44L • MIXERS. Centrifugals, continuous, and batch mixers for chemical processing. Also equipment for rayon production.
Baker Perkins, Inc.

45A • HEATING MEDIUM. Heat transfer medium makes alternate heating and cooling possible in the same equipment.
The Dow Chemical Co.

46A • CHEMICAL PORCELAIN PULSAFEEDER. Chemical towers and tower plates, Raschig rings, valves and pipe, and controlled-volume pump.
Lapp Insulator Co.

48A • TOWERS. Haveg cylindrical and rectangular tanks and towers, pipe and fittings, valves and pumps, fume duct systems, heat exchangers.
Haveg Corp.

49R • CONNECTIONS FOR CHEMICAL PIPING. Gaskets, expansion joints, flexible couplings, and adaptors.
United States Gasket Co.

50L • YORKMESH DEMISTER. For mist separation in vacuum towers.
Otto H. York Co., Inc.

51A • NI-RESIST CAST METAL. Offers various combinations of useful engineering properties. Booklets.
The International Nickel Co., Inc.

52L • CENTRIFUGES. Developed for centrifugal separation of various blood components and plasma proteins.
The Sharples Corp.

58A • CONVEYING PROBLEMS. Mikro line of pneumatic conveying equipment. For conveying large bulks of materials from processing to storage, or from cars to storage.
Pulverizing Machinery Co.

63A • SPRAY DRYERS. Twenty-one recent Bowen spray dryer installations illustrated. Booklet.
Bowen Engineering, Inc.

65A • FINTUBE SECTIONAL HEAT EXCHANGERS. Permits one group of sections after another to be taken off-line, and cleaned, while the rest carry the exchanger's full rated capacity. Bulletin.
Brown Fintube Co.

Chemical Engineering Progress

Numbers followed by letters indicate advertisements, the number corresponding to the page carrying the ad. This is for ease in making an inquiry as you read the advertisements. Letters indicate position—L, left; R, right; T, top; B, bottom; BR, bottom right; BC, bottom center; TR, top right; TL, top left; A indicates a full page; IFC, IBC, and OBC are cover advertisements.

Be sure to give name, address, position, etc.

Remember, the numbers on the upper portion of the card bring you data on the bulletins, equipment, services, and chemicals exhibited at the Chemical Exposition. The lower portion of the card is for the advertised products, and is keyed not only to advertising pages, but also to the memory-tickling list under the heading Products.

66A • ACID HANDLING PROBLEM. Pyrex brand glass pipe, designed for full-scale production operations. Available in six standard sizes from 1- to 6-in. I.D., inclusive.
Corning Glass Works

69A • FLUOSOLIDS. Installation roasts pyrite to produce SO_2 for acid manufacture and a desulfurized calcine for iron manufacture.
The Dorr Co.

70A • DRYING PROBLEMS. Drying research laboratory.
C. G. Sargent's Sons Corp.

71A • METERING. Pneumatic electric metering system for flow measurements. Bulletin.
Republic Flow Meters Co.

73A • STEEL-BELT CONVEYOR. Solid band of flat, stainless or carbon steel. Water-bed arrangement which cools from beneath.
Sandvik Steel, Inc.

74L • MIXING CYLINDER. For dispersion and blending of powdered and fibrous materials, as in coating of fiber with carbon black.
Paul O. Abbé, Inc.

75A • GRAPHITE ANODES. Graphite anodes for the electrolytic industry in making chlorine and caustic soda for antiknock compounds.
Great Lakes Carbon Corp., Electrode Div.

77A • ROTARY DRUM VACUUM FILTER. For free-filtering liquids which are not too hot for vacuum filtration. Continuous automatic operation.
Process Equipment Div., General American Transportation Corp.

78L • HUMIDITY CONTROLLER. Controlled humidity method using hygrol moisture-absorbent liquid.
Niagara Blower Co.

79A • RATOGRAPHIC MINIATURE RECORDER. Miniature instrument handles 4 separate signals.
Fischer & Porter Co.

80A • PUMPS. Variable stroke triplex pump handles any free-flowing liquid to discharge pressures from 300 to 15,000 lb./sq.in. Accumulators also available. Data Sheets.
The Aldrich Pump Co.

81A • ANTI-BIOTIC DRYER. Unit designed to remove an organic solvent from an anti-biotic.
The C. O. Bartlett & Snow Co.

82L • CENTRIFUGAL SEPARATOR. Opening and closing bowl eliminates valves, permits continuous discharge of drier sludge. Automatic time switch.
Centrico, Inc.

(Continued on back of this insert)

Please do not use this card after April, 1954

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Advertisers' Products

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12A	13A	14A	15R	16A	56BA	25A	27A	28A
29A	31A	32A	35A	36A	37A	39A	40L	41A
43A	44L	45A	46A	48A	49R	50L	51A	52L
58A	63A	65A	66A	69A	70A	71A	73A	74L
75A	77A	78L	79A	80A	81A	82L	83R	84L
85A	86L	87R	88L	89A	90L	90TR	91R	92L
92TR	92BR	93R	94T	94B	95BL	95R	97L	97R
99L	99R	100L	101T	101BC	101BR	102T	102B	103R
104L	104TR	104BR	105T	105B	106T	106B	107TL	107R
110T	110B	111BR	IBC	OBC				

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Company ....

Address ....

City .... Zone ..... State ....

November, 1953

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Advertisers' Products

IFC	3R	4L	5A	6A	7A	8L	9A	10A
12A	13A	14A	15R	16A	56BA	25A	27A	28A
29A	31A	32A	35A	36A	37A	39A	40L	41A
43A	44L	45A	46A	48A	49R	50L	51A	52L
58A	63A	65A	66A	69A	70A	71A	73A	74L
75A	77A	78L	79A	80A	81A	82L	83R	84L
85A	86L	87R	88L	89A	90L	90TR	91R	92L
92TR	92BR	93R	94T	94B	95BL	95R	97L	97R
99L	99R	100L	101T	101BC	101BR	102T	102B	103R
104L	104TR	104BR	105T	105B	106T	106B	107TL	107R
110T	110B	111BR	IBC	OBC				

Name ....

Position ....

Company ....

Address ....

City .... Zone ..... State ....

November, 1953

PRODUCTS *(Continued)*

83R • HIGH-ALLOY CASTINGS. Furnace rollers, heat treating trays, furnace shafts, annealing belts, retorts, and tubing.
The Duraloy Co.

84L • DUST COLLECTOR FABRICS. For hot or corrosive materials.
Filtration Engineers, Inc.

85A • STAINLESS TUBING. Features tubing used for field testing in the petroleum industry; for Blood Plasma Sterilizer, and for processing highly corrosive glutamic acid.
The Carpenter Steel Co.

86L • FROM PIPING TO COMPLETE PLANT. Pipe, duct, and fittings, towers, absorbers, scrubbers, separators, reactors, kettles, surge tanks, linings and tower packings.
Maurice A. Knight.

87R • LIQUID OXYGEN PUMPS. Vertical top-suction liquid oxygen pumps.
Lawrence Pumps, Inc.

88L • U. S. VARIDRIVE MOTORS. Asbestos-protected motor with a built-in speed control.
U. S. Electrical Motors, Inc.

89A • PURE WATER PRODUCTS. Mixed-bed demineralizers, automatic water still, and "Ventgard" purity safeguard.
Barnstead Still & Sterilizer Co.

90L • PLA-TANK STACKS. Manufactured from resin-bonded glass fiber. Resistant to a wide variety of fumes and temperatures. Data file sheet.
The Chemical Corp.

90TR • PLATE FABRICATION. Towers, pressure vessels, general plate fabrication and heat exchangers.
Downingtown Iron Works, Inc.

91R • DIAPHRAGM VALVES. Lever operated valve provides throttling when required. Choice of fifteen diaphragm materials.
Hills-McCanna Co.

92L • TRANSPARENT FLEXIBLE TUBING. Made of polyvinyl chloride and stocked in 40 sizes from .120 to 2 in. I.D.
Couse & Bolten Co.

92TR • MECHANICAL AND PROCESS EQUIPMENT. Complete engineering service. Brochure.
Engineering Corporation of America

92BR • STEAM JET EJECTORS. Condensers and vacuum equipment. Corrosion resistant parts interchangeable with standard parts.
The Jet-Vac Corp.

93R • TANK GAUGE RECEIVERS. Thirty-six key-type switches. Easy custom panel installations when desired.
The Vapor Recovery Systems Co.

94T • WEIGHING AND PROPORTIONING DEVICES. For granular and liquid materials. Weighing, batching, proportioning or feeding problems.
Glengarry Equipment Corp.

94B • SPRAYING. Spray nozzles designed for particular spray pattern, impact, spray angle and capacity. Catalog.
Spraying Systems Co.

95BL • CRUSHERS. Precise reduction for experimental labs, pilot plants, test runs.
American Pulverizer Co.

95R • CATALYSTS. Catalysts and service to help with all catalyst problems.
The Girdler Co.

97L • HARDINGE WORKING MODELS. Features auto-raise thickener, automatic backwash sand filter, and Ruggles-Coles rotary dryer. On display at the Chem. Show.
Hardinge Co., Inc.

97R • INDUSTRIAL WORK CLOTHING. Shirt and trousers or coveralls resistant to acids, caustics, grease, oil, and dirt. Free trial garment.
American Allsafe Co., Inc.

99L • MIST ELIMINATOR. Liquid carry-over controlled by separators made of knitted wire mesh.
Metal Textile Corp.

99R • AIR HEATING FURNACES. Capacities from 600,000 to over 100,000,000 BTU'S.
Air Devices, Inc.

100L • DUST AND FUME ELIMINATORS. Vertical rotor units for dust and fume collection and elimination.
Schmieg Industries, Inc.

101T • SPECIAL PROCESSING PROBLEMS. Resources for fabrication, including modern shop equipment for heavy sheet metal forming, specialty welding, and all machinery operations.
Artisan Metal Products, Inc.

101BC • CRUSHERS. Up to 15 tons/hr. Takes up to 16 in. chunks. Adjustable output: ½ in. to 3 in. For any chemical or foodstuff.
Franklin P. Miller & Son, Inc.

101BR • TURBO-DRYER. For granules, beads, powders, crystals, pastes, sludges, and slurries.
Wyssmont Co.

102T • FILTER PRESSES. Filter to recover solids, clarify, purify, wash or extract; and steam, melt or redissolve the cake.
T. Shriver & Co., Inc.

102B • INDUSTRIAL BALANCES. Micrometer-poise balance for speedy determination of weight.
Ohaus Scale Corp.

103R • GEMCO VALVES. Accurate seating without the use of shims. Straight-through, clear passage for maximum flow. Also manufactured for pressure, vacuum or high temperature requirements.
General Machine Co. of New Jersey

104L • ANTIFOAM. Defoamers for the process industries. Free sample.
Dow Corning Corp.

104TR • MULTI-PATH TRAY PACKING. Combines characteristics of bubble trays and conventional packings.
Fractionating Towers, Inc.

104BR • GATE VALVE. Made of cast steel and built to A.S.A. gate valve specifications. Available in sizes from ½ in. to 12 in., flange type.
Vernon Tool Co., Ltd.

105T • FILTRATION. Complete range of filter bases and a choice of six different closing devices. Catalog.
D. R. Sperry & Co.

105B • PLASTICIZER OIL. Compatibility with GRS, neoprene, and buna N type rubbers.
Pan American Refining Corp.

106T • PORO-STONE FILTER. Used for the mechanical separation of solids from all types of chemical liquids. Bulletin.
R. P. Adams Co., Inc.

106B • HYDROSTATIC GAUGES. For pressure, vacuum, draft depth and absolute, barometric, and differential pressure. Bulletins.
Uehling Instrument Co.

107TL • PROCESSING MACHINES. Pulverizers, mixers, blenders.
Gruendler Crusher & Pulverizer Co.

107R • POLYETHYLENE PUMPS. Fluid contacts only outer surface of molded flexible liner and inside of pump body block. From fractional to 20 gal./min.
Vanton Pump and Equipment Corp.

110T • NICHOLSON TRAPS. Five types for every application, process, heat, power. Sizes ¼ in. to 2 in.; pressures to 250 lb.
W. H. Nicholson & Co.

110B • AGITATOR DRIVES. Double and triple reduction drive unit.
Western Gear Works

111BR • CHILL-VACTOR. Steam-jet vacuum unit to flash-cool water and other liquids through temperatures down to 320° F.
Croll-Reynolds Co., Inc.

IBC • CONTROLLED VOLUME PUMPS. Submerged controlled volume pump, and extended range controlled volume pumps for high pressure applications.
Milton Roy Co.

OBC • FLUID MIXING. Side entering mixers, sizes 1 to 25 hp. Portable mixers, sizes ⅛ to 3 hp. Catalogs.
Mixing Equipment Co., Inc.

(*Continued from page 57*)

hoods, tank liners, plating racks. Colonial Plastics Mfg. Co., Division of Van Dorn Iron Works. Booths S-2 & S-41.

33 • BLENDERS. Recently designed blender unit, including a dry blender featuring either variable speed or direct gear head motor drive totally enclosed, & dual-angle variable pitch rotating hopper assembly. Adjustment for dispersion of varying materials with correct blending angles. Also a new strip packaging unit, two new types of rotary presses, & rotary granulator. Arthur Colton Co. Booth 301.

34 • MASS SPECTROMETER. New mass spectrometer for monitor & control of continuous processes in chemical plants & oil refineries. Makes immediate measuremnt of process-gas constituents. Consolidated Engineering Corp. Booth 335.

35 • MASS FLOW METER. Instrument for measuring mass flow rate of any substance flowing or falling through pipe. Responds only to pounds, insensitive to temperature, pressure, viscosity or external acceleration. Direct reading in pounds per minute can be made on gases, liquids, slurries. Control Engineering Corp. Booth 821.

36 • CASTINGS, VALVES, FITTINGS. Display of stainless steel castings, valves & fittings. Explanation of development of shell molding, V2B alloy and Quikupl. Cooper Alloy Foundry Co. Booth 602.

37 • EJECTORS & EVACTORS. Single-stage ejectors of Haveg, & single-stage evactor of carbon, including nozzle. Transparent color view of vacuum refrigerating system. Also two-stage, noncondensing evactor using steam at 10 lb. gauge in first stage, water at 35 lb. gauge in second stage. Croll-Reynolds Co., Inc. Booths 236 & 437.

38 • DEHYDRATING EQUIPMENT. Pictures of all dehydration units available, & a wooden model of a continuous press, which can be opened to exhibit principle of operation. Davenport Machine and Foundry Co. Booth 443.

39 • THERMO-PANEL PLATE COILS. Thermo-panel plate coil for tank heating & cooling. Eliminates pipe coiling, easily replaced & cleaned. Light weight & available in special shapes & wide range of materials. Typical application, radiant cooling panels around furnaces used for manufacture of glass or steel. Dean Products, Inc. Booth S-111.

40 • HEAT EXCHANGERS. Carbon cubic heat exchanger, including sets of headers with varied pass arrangements and lining materials of carbon, lead, glass & rubber. Operating pressures to 200 lb./sq.in.gauge. Unit compact, requiring one eighth floor space of conventional shell and tube. Delanium Carbon Corp. Booth 648.

41 • DORR EQUIPMENT. A type TM Dorr-Clone in operation, with samples of results on several materials. Flow chart of Dorrco FluoSolids system; Scale model of phosphoric acid & granular fertilizer plant. The Dorr Co. Booth 514.

42 • DISPLACEMENT PUMPS. Self-priming positive displacement pumps of stainless steel & bronze with interchangeable impellers of Du-Pont Hypalon & Monel. Used for pumping rocket fuels, hydrogen peroxide in all concentrations, fuming red nitric, etc. Also stainless faucets, Telflon-based-thread sealing & caulking compounds. Eco Engineering Co. Booth 647.

43 • PRESSURE FILTERS. Leaf-type pressure filters in sizes from 12 to 72 in. diam. Lined with rubber or plastic, special conebottom discharge, quick-opening covers. Chemical & food process industries, sugar refineries, etc. Multitube heat exchangers also shown. Enzinger Union Corp. Booth 232.

44 • SCALES. Automatic net weighing machine capable of 1/32-oz. sensitivity, equipped with magnifying ratio indicator for easy reading of fractional variations. Also automatic filling machine control system. Exact Weight Scale Co. Booth C-12

45 • TUBE & SHELL EXCHANGERS. Exhibit of Impervite tube & shell exchangers, a Cascade cooler, blowup of standard model pump, together with many parts & fittings. Falls Industries, Inc. Booth 37.

46 • INSTRUMENT PANELS. Display of electric housings, instrument panels, cubicles, control cabinets in steel and aluminum. Heli-arc welding on aluminum. Falstrom Co. Booth 75.

47 • CONTROLS. Miniature thermoswitch controls & Detect-A-Flo control for air flow or liquid level. Presents new approach to control & detection of air flow & liquid level. Hermetically sealed, resistant to dirt & corrosion, self-contained. Fenwal, Inc. Booth 909.

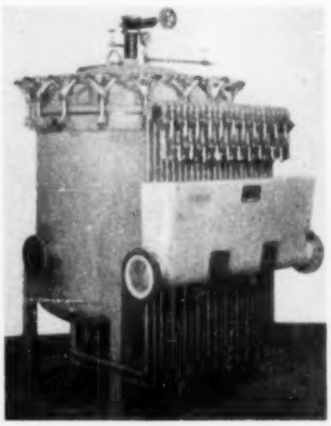
48 • CONTROL INSTRUMENTS. Instruments for measurement & control of liquid levels, granular solids, viscous fluids & powders; moisture content, conductivity, pH, etc., control. Six-point & twenty-four-point circular chart recorders both as Tektologs and as a.c. self-balancers. Tektor electronic level control, Telstor electronic level indicator. A new proximity meter & capacitance guide. Fielden Instrument Division of Robertshaw-Fulton Controls Co. Booth 448.

49 • VACUUM FILTER. Horizontal rotary vacuum filter & several new Orlon dust-collector cloths & bags for hot & corrosive materials. Filter is for coarse crystalline materials, fibrous pulps & other free-filtering applications. Filtration Engineers, Inc. Booth 3.

50 • QUARTZ FILTER MEDIA. Porous carbon filter media, plates, & tubes, for caustic & acid filtration, precoat filtration & filtration of hot alkaline gases, etc. Also porous calcined refractory clay, porous thermoplastic filter media; Filtro synthetic bond quartz air diffuser plates & tubes for activated sludge sewage treatment; synthetic-bond quartz underdrain plates for water filtration. Filtros, Inc. Booth 419.

51 • EXPANSION JOINTS. Expansion joints with Kel-F protective coating for conditions of constant motion Other new products will be stainless steel, light-weight, high-tensile strength, straight wall tubing. Also flexible metal hose in thicknesses .008 to .025 in.

Laboratory-size Simpson LF Mix-Muller of National Engineering.



Enzinger-Union leaf-type pressure filters lined with rubber or plastic.

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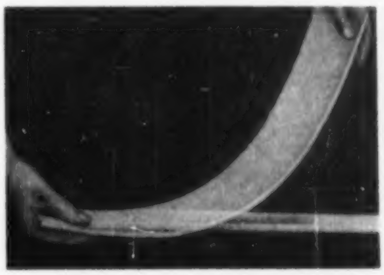
By using the postage-free request card for the equipment described here complete literature will be mailed to you.



Porous thermoplastic filter media from Filtros.

¼ to 6 in. diam. Brass & stainless bellows. Flexonics Corp. Booth 643.

52 • GATX PRODUCTS. Exhibits & demonstrations from each division serving chemical industry. Kanigen chemical plating of nickel used to repel corrosion & degeneration of low-cost base metals. Pilot Conkey evaporator element. Storage structures, Louisville dryer unit, Turbo-Mixer counter-current extraction unit, & a model of Airslide covered hopper car for bulk shipping of dry materials. General American Transportation Corp. Booth 42-44.

53 • LABORATORY INSTRUMENTS. Brookfield centipoise viscometer; Ardco polarograph for measuring any reducible ion. Single pan, rapid weighing analytical balance. General Laboratory Supply Co. Booth 640.

54 • HEAVY-DUTY GLASS-LINED STEEL REACTOR, 200 gal.; a 10-gal, pilot plant reactor; plus a laboratory reactor. Also glass-lined steel column featuring new glass-coated-steel support for packing plates. Glascote Products, Inc. Booth 106.

55 • PROPORTIONING & WEIGHING. Equipment for proportioning & weighing solids & liquids in packaging, batching, feeding dry chemicals, liquids, food products. Units range from 1 oz. to 500 lb. Micro feeder handles liquid from 0 to 50 cc./min. Applied to proportioning & feeding definite ratio of liquids or dry materials. Glengarry Equipment Corp. Booth 517.

56 • STEAM-JACKETED KETTLES. Stainless steel steam-jacketed kettles with agitators, & special kettle combining single & double motion agitator. Available to chemical processors for trial without charge other than freight. Reservation for use of unit can be made at show. Groen Mfg. Co. Booth 917.

57 • CRUSHING MACHINES. Equipment for processing dry powdered or granular materials. On display a new Gump all-metal rotary sifter, Draver volume proportioning feeders, Bar-Nun Auto-Check & Edtbauer-Duplex net weighers, Vibrox barrel packer & a unit weight conveyor. B. F. Gump Co. Booth 23.

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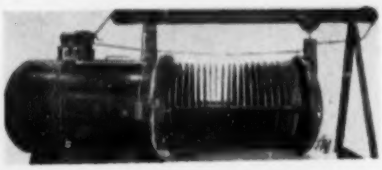
For most of the equipment described here, the manufacturers have available complete bulletins and catalogs.



Niagara filter for liquid clarification.

58 • SHUTOFF VALVES. Visible shutoff line-blind valves which cannot leak to downstream side. Expansion, contraction, & erosion do not affect true seating. No internal crevices to collect sediment. Hamer Oil Tool Co. Booth C-127.

59 • TRAY-BELT FILTER. Gyrotor air classifier & full-size tray belt filter. Animated display of both units. Also models of Hardinge automatic backwash sand filter & Auto-Raise thickener & Ruggles-Coles rotary dryer. Hardinge Co., Inc. Booth 4.

60 • DISC SEPARATOR. Laboratory model Carter disc separator. Makes separations on granular free-flowing materials on a length basis. Hart uniflow separator makes similar separations; Carter precision grader makes thickness and width separations. Also equipment for grading & separating cubed & pelleted materials. Hart-Carter Co. Booth C-41.

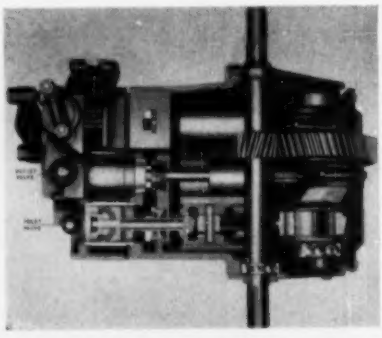
61 • FILTERS. Roto-jet filter self-cleaned internally with spray jets; an all-plastic-sheet filter, acid, corrosion & heat (to 300°C) resistant. Pharmaceutical and laboratory filters for filtering blood plasma, serums, antibiotics. Also plastic-sheet filter with asbestos filter media. Hercules Filter Corp. Booth 78.

62 • GATE VALVE. New style all-jacketed gate valve. Simplifies replacement of valve seats by insert in valve body. Installed without removing valve from line. Various metals up to 4 in. line size. A 6-in. size or more fabricated from carbon or stainless. Available 1½- to 10-in. line size. Hetherington and Berner, Inc. Booth 347.

63 • CYCLONES & CENTRIFUGALS. A 50-in. Reineveld centrifuge from Holland. Control panel for visitors. Also operating model of cyclone thickener. Heyl & Patterson, Inc. Booth S-37, S-38.

64 • HIGH-PRESSURE FITTINGS. Valves for 30,000 and 60,000 lb./sq.in., with calibrated control & new signal system of handles for coding lines. Method of matching orifice settings from various runs. High Pressure Equipment Co. Booth C-135.

65 • PACKLESS VALVES. For high vacuum & corrosive fluid applications, packless valves both diaphragm & bellows types. Stainless steel, Monel & brass. Also new bar stock valve with O-ring seal & self-aligning spindle. Line of toggle, check, & relief valves. For refineries, stainless steel sampling cylinders for high and low pressures. Hoke Inc. Booth 935.



John Bean high-pressure reciprocating pump.

66 • GRAVITY FILLER. Standard units plus new filler adding sulfuric acid to 1-qt.-plastic containers for dry charged auto batteries. Fill is by gravity flow. Accurate to ± 1/64 in. Completely automatic. Horix Mfg. Co. Booth C-113.

67 • HEATING FLUID. Showing of hot oil heaters, a new approach to high temperatures (to 600°F) in process heating, thermally stable, always in hydraulic balance at atmospheric pressure. Endothermic & exothermic reactions can be served simultaneously. Safe, flexible, complete thermostatic controls & safety switches. Hot Oil Heater Co., Inc. Booth C-132.

68 • DEIONIZING EQUIPMENT. Mixed-bed deionizing equipment, display of new applications of ion-exchange to industrial processes; information on package-type-deionizing equipment, & large-scale installations. Also a mixed-bed cartridge-type laboratory deionizing unit. Illinois Water Treatment Co. Booth 630.

69 • COMPRESSORS, CONDENSERS, EJECTORS. Forty types of valves; nonlubricated compressors, condensers, & ejectors, pumps, paving breakers, rock drills, air & electric tools. Models will be cutaway to show features of each unit. Also pumps, especially for process industries. Ingersoll-Rand Co. Booth 918.

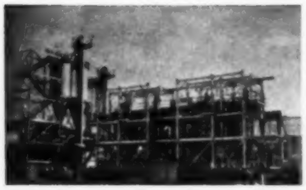
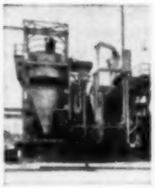
70 • FORCED-RECIRCULATION, HIGH-TEMPERATURE GENERATOR, PACKAGED UNIT. Applicable to Dowtherm vaporizer; thermal liquid heater for process temperatures to 750°F., high-temperature hot-water generator, or high-pressure steam. Features forced recirculation system & response to load or temperature changes. International Boiler Works Co. Booth 548.

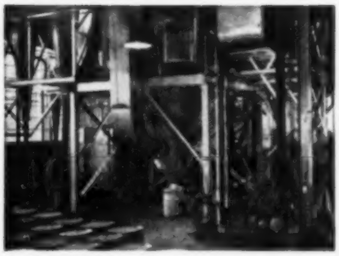
71 • ROTARY PUMPS. Small rotary pumps in bronze & stainless steel with neoprene impellers. New 2-in. bronze, & ⅜-in. plastic pump. Jabsco Pump Co. Booth 326.

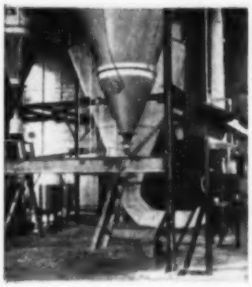
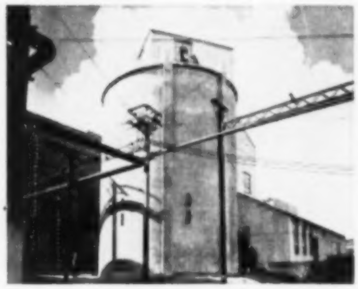
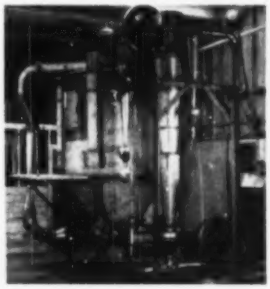
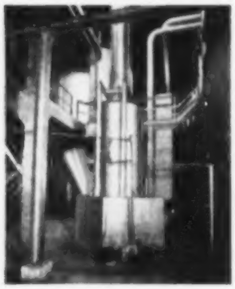
72 • SPECTOGRAPH. Information on new spectograph for high dispersion work, isotope analysis, low concentration, and study of line shapes. Covers long wavelength section. Also new source unit, a recording microphotometer with photomultiplier system. Jarrell-Ash Co. Booth 745.

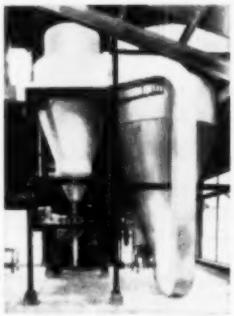
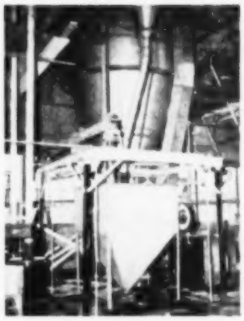
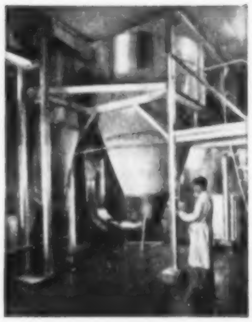
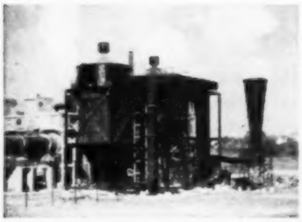
73 • CRUSHING MACHINERY. On display swing hammer pulverizer for heavy duty & large capacities; Waytrol constant-weight gravimetric feeder; an electric vibrating barrel packer; electric vibrating pan feeder run-around; mechanical vibrating conveyor; indirect cooler & direct dryer sections. Jeffrey Mfg. Booth 201.

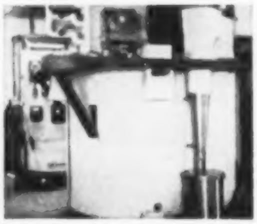
(Continued on page 64.
Use postcard on page 59)

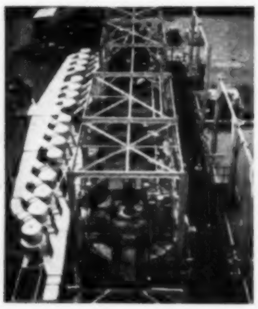
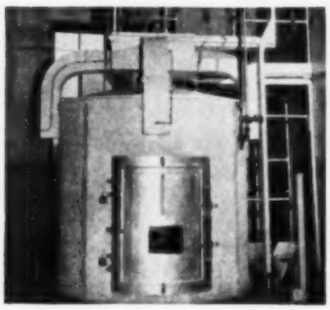
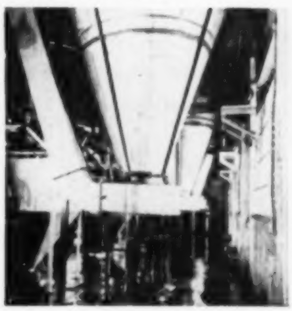
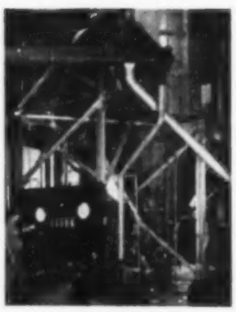



(Continued from page 62B)

74 • EJECTORS. Ejector equipment designed so that standard cast-metal parts are interchangeable with parts lined with corrosion-resistant materials. Enables corroded parts to be replaced with resistant pieces at minimum expense. Jet-Vac Corp. Booth 320.

75 • FLOOR MAINTENANCE. Complete line of floor machines for waxing, scrubbing & polishing, & vacuum cleaners for wet and dry pickup. Kent Co., Inc. Booth S-72.

76 • PIPE FITTING. Forged & seamless welded pipe fittings for corrosion-erosion service in chemical process industries. Wide range in carbon, stainless, alloys, & nonferrous metals. Ladish Co. Booth 24.

77 • PUMPS. Horizontal propeller pumps, vertical top-suction pumps, & liquid-oxygen pumps. Lawrence Pumps Inc. Booth 318.

78 • PAINT & INK MILLS. Floating roll, horizontal, three-roll Sight-O-Matic paint & ink mills. Roll adjustments flexible to permit different pressure between feed & take-off rolls; convertible to a two-point adjustment with self-positioning center roll. J. M. Lehmann Co. Booth S-78.

79 • INFRARED ANALYZER. Four electric tube infrared nondispersion analyzer featuring selectivity & accuracy. For analyzing CO, CO_2, CH_4, N_2O, C_2H_6, etc. Sensitivities to 1/3 p.p.m. Liston-Becker Instrument Co., Inc. Booth 824.

80 • FLEXIBLE COUPLINGS. Flexible couplings for 1/6 to 2500 hp. plus a display of universal joints in thirteen sizes; variable speed pulleys sizes fractional to 8 hp. & ratios of 3:1. Variable-speed transmissions fully enclosed, fractional to 5 hp. Lovejoy Flexible Coupling Co. Booth S-71.

81 • BUNA-N RUBBER. Buna-N heat & corrosion-resistant compound for molded pipe, fittings, valves, pumps, linings, etc. Withstands variety of corrosive chemicals, oils at temperatures to 225°F. Luzerne Rubber Co. Booth 409.

82 • OVENS & DRYERS. Glass annealing ovens & cabinet tray dryers. Electrically heated, (200°F.) cross flow air circulation, automatic temperature control, for plastic molding & extrusion powders, pharmaceuticals, ceramics, general laboratory use. Ovens for glass annealing, decorating, heat treating, etc. Lydon Brothers, Inc. Booth 735.

83 • DAYLIGHT LAMP. Desk-top lamp producing north sky daylight for color matching. Titration *p*H meters; color, & black & white, densitometer; disk colorimeter, etc. Macbeth Corp. Booth 833.

84 • LABORATORY APPARATUS. Bronwill Warburg apparatus & manometers; heating tapes; auto pipettes & burettes with Teflon stopcock, also in Schellbach-type glass; polyethylene funnels, homogenizer for micro-macro use. E. Machlett & Son. Booth C-33.

. . . going to the show? . . . then use the Data Service as a guide . . . read our brief descriptions and talk to the company representatives at the show—and if you can't see all you planned—use our card to bring it to you in the mail.

85 • LIQUID-LEVEL CONTROL. Liquid-level control for liquid nitrogen also handles crudes to lightest hydrocarbons from −300° F. to +1400°F. and from vacuum to 15,000 lb./sq. in. Type for sump applications uses glazed porcelains, Karbate, or neoprene displacers instead of floats. Magnetrol Inc. Booth 423.

86 • VIBROLATORS. Rotary pneumatic vibrators called vibrolators, for sifting operations, mold release, feeding, compacting, etc., will feature the exhibit. Also displayed will be a tuned reed vibration indicator of pocket size, which gives direct reading of cycles per minute, from 2,000 to 5,000. Martin Engineering Co. Booths C-138—C-140.

87 • CENTRIFUGAL SEPARATOR & SCREEN. A first showing in the U. S. of the TrT (Trenntechnik) continuous nozzle discharge centrifugal separator & screen. The TrT centrifugal screen is capable of drying aluminum sulfate to about 1% moisture, handles 2000 to 2500 gal./hr., 4 to 5 tons of dry salt crystals. Also dries pulps. Merco Centrifugal Co. Booth 2.

88 • LABORATORY EQUIPMENT. Demonstration of new Interflex cabinets & ways to alter with simple tools. Also Airo-Balanced fume hood, features supplementary air ducts permitting entry of outside air against room pressure. Allows air conditioning and heating systems to operate normally. Metalab Equipment Corp. Booth 901.

89 • MIST ELIMINATORS. Demonstration of entrainment removal by mist eliminators. Tower with controls over wide range of velocities. Also two new developments in mist eliminators. Metal Textile Corp. Booth C-65.

90 • PROTECTIVE COATINGS. Coating services including application of synthetic resin coatings; rubber linings; metallizing, sandblasting & welding. Metalweld, Inc. Booth 240.

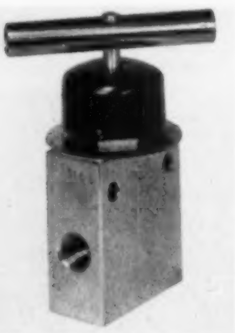
91 • CRUSHERS. Designed especially for the chemical & foodstuff industries, crushing & breaking machine for materials such as maleic anhydride, para dichloro benzine, wax, tars, etc. Accepts hard or soft materials. In stainless steel or tinned construction for foodstuffs and pharmaceuticals. Franklin P. Miller & Son, Inc. Booth S-3.

92 • CONTROLLED VOLUME PUMP. A high pressure & capacity, controlled-volume pump with range of 1,450 gal./hr. at 470 lb./sq.in. to 14 ga./hr. at 50,000 lb./sq.in. Constant- or variable-speed motors, & automatic or manual dial stroke length adjustment while running. Shown also is a submerged controlled-volume pump for use with corrosive fluids. Liquid end is submerged, eliminating stuffing box leakage. Milton Roy Co. Booth 313.

93 • GAS & LIQUID ANALYZER. An infrared & gas analyzer for automatic analysis of fluid mixtures. Controls continuous or batch-type processes, measures toxic contaminants in atmospheres. Also a Lira-type analyzer; an oxygen analyzer, combustible gas alarm, portable instruments, etc. Mine Safety Appliances Co. Booth C-32.

94 • RECORDING INSTRUMENTS. New instruments on display: low-range radiamatic unit and recorder; Pyr-O-Vane millivoltmeter-type controllers; new ElectroniK strip chart recorder with electrically operated chart speed mechanism; Tel-O-Set miniature instruments; ElectroniK 90-point scanner, & new Honeywell diaphragm motor valves. Minneapolis-Honeywell Regulator Co. Booths 836-840.

(Continued on page 68. Use postcard on page 59)



High Pressure Equipment Co. valve with calibrated control; 30,000 lb./sq.in.

Liston-Becker four-electric-tube infrared nondispersion analyzer.

How a Georgia chemical company solves

For seven years the engineers at the Chemical Products Corporation plant in Cartersville, Ga., grappled with the difficult problem of handling a 32% hydrochloric acid solution containing traces of organics.

Three years ago, after successful tests, they installed PYREX brand "Double-Tough" glass pipe for this liquid-handling job—and solved the problem satisfactorily.

The hydrochloric acid (20° Bé.) is produced as a byproduct of a benzene chlorination operation, condensed from gas to liquid form. It is piped some 600 feet through the 2" PYREX pipeline, stored in outdoor tanks and used as required in other manufacturing processes.

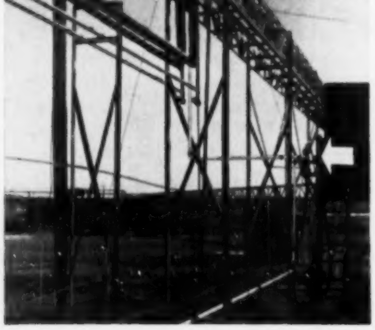
Outdoor temperatures ranging from 0° to 100° F. are encountered in this service. The acid itself is not heated.

Cost of maintenance cut to bone

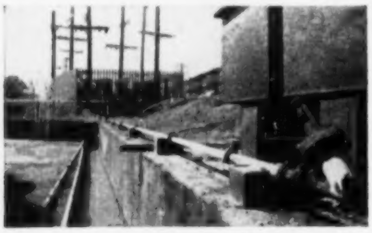
During its three years of service the PYREX pipe has required no maintenance traceable to its use. The metal flanges and pipe joints are coated with Insulmastic paint for protection against atmospheric corrosion and possible gasket leaks.

Chemical Products Corporation is one of hundreds of chemical companies that have found the most satisfactory answer to such severe pipeline corrosion problems by installing PYREX brand glass pipe. If you have stubborn problems of this nature, the information on the next page may interest you. Mail the coupon today for more detailed information.

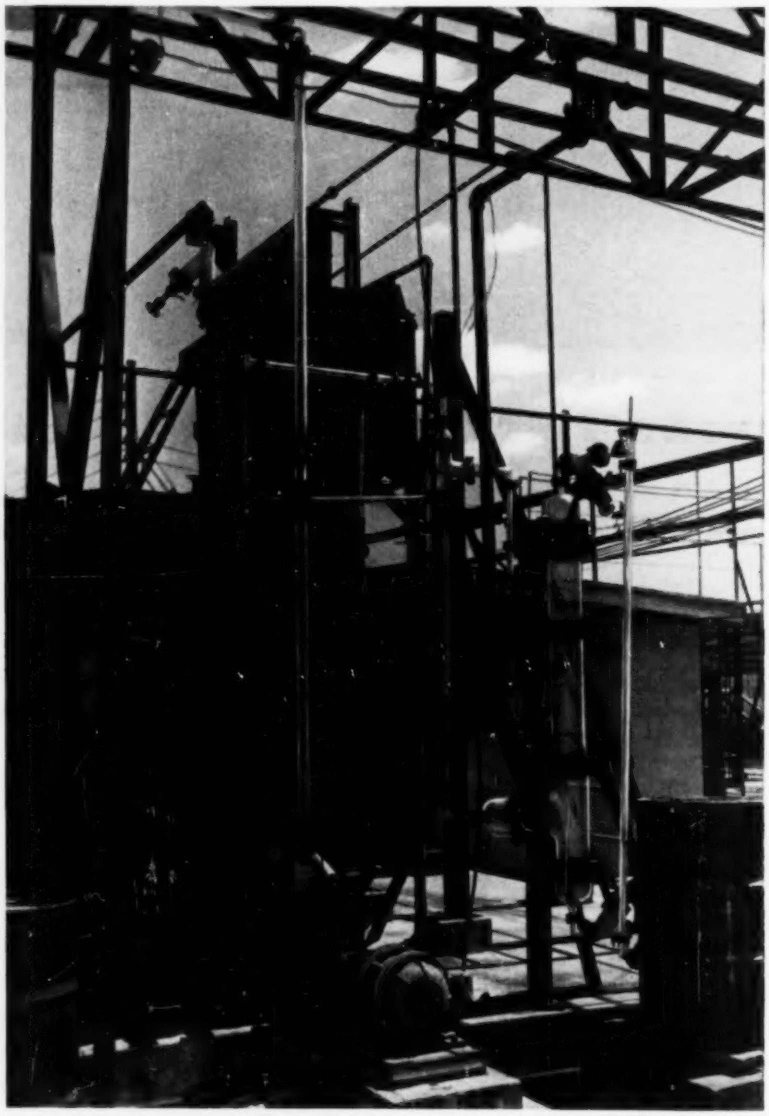
A portion of the 450-foot bridge which carries the PYREX *pipeline from condenser storage to processing storage 600 feet away. (The last 150 feet of the line is on ground-level supports.)* The severity of the corrosion problem involved in this liquid handling is due to traces of organics remaining in the HCl.



Midway in its descent from the bridge to the ground level supports, the PYREX *line carries a valve and hose for unloading tank cars and tank trucks when necessary.*



The final turn of the long PYREX *pipeline discharges the HCl solution into three 1,000-gallon tanks. (The picture shows a corner of one of them.) Much of the credit for Chemical Products Corporation's trouble-free experience with this* PYREX *pipe installation is due to a well designed system of supports for the line.*



System of PYREX *pipe which serves the plant-assembled* PYREX *gravity separator (visible at right of above picture) where hydrochloric acid is separated from organic liquids carried over from a benzene-chlorine reaction. The pump in the foreground pumps the acid through the long pipeline shown in the other pictures.*

a severe acid handling problem

This pipe ends corrosion problems

Recent years have seen a remarkable increase in appreciation of the fact that the characteristics which dictate the choice of glass in laboratory applications, apply equally well to the handling of corrosive or sensitive fluids in industrial processes.

PYREX brand "Double-Tough" glass pipe, designed for fullscale production operations and doubled in strength by end-tempering, has repaid its cost many fold in a great variety of chemical handling operations.

Remarkable corrosion resistance reduces pipeline replacements

The story of the Chemical Products Corporation's PYREX pipe experience, on the opposite page, demonstrates one of the common advantages:—*elimination of periodic replacements of pipeline because of acid corrosion.*

Other advantages

Non-Contamination—Most materials will not stick to the smooth, hard surface of PYREX pipe. Surface deposits either do not build up or are easily removed. It is simple to clean and sterilize. It neither gives nor picks up any measurable taint of color, taste or odor.

Transparency—Where it is important to see the flow of material in a pipeline, the clear transparency of PYREX pipe is essential. Visual demonstration of internal cleanliness is often desirable.

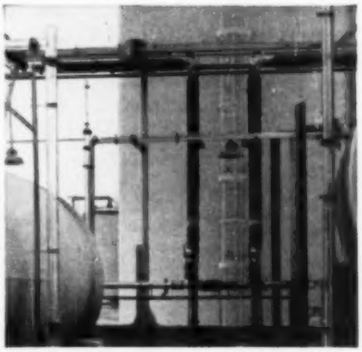
Operating temperatures—PYREX brand piping is operating satisfactorily in outdoor installations with temperatures of less than 0° F., and in indoor installations with liquids at temperatures as high as 250° F., and higher in special cases.

Installation—PYREX pipe is easy to install and low in installed cost compared with other corrosion-resistant materials. It is available in six standard sizes from 1- to 6-inch I. D., inclusive.

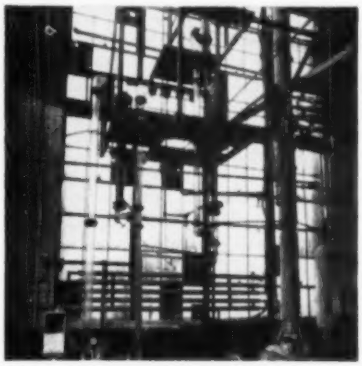
Detailed information yours for the asking

Since it is to your advantage to weigh the inherent and relative advantages against the disadvantages of any pipeline material before making an installation, we invite you to discuss your particular problem with a PYREX pipe representative at your convenience.

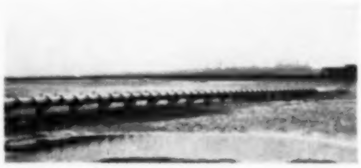
Meanwhile, the literature listed on the return coupon at right will give you many more facts than there is room for here. Just check the items you would like to receive, fill out the coupon and we will act promptly upon its receipt.



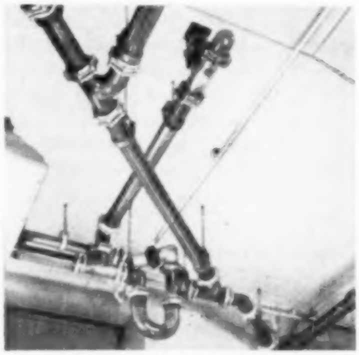
Monochloro benzene — operating conditions 230° F. at 30 p.s.i.



Chlorinated organic compounds



Acid fume disposal line



Hydrochloric acid, ferric acid, nitric acid drain lines

The following conveniently located distributors stock and sell PYREX pipe and fittings. Contact the one nearest you for full information.

BELMONT, CALIFORNIA
Glass Engineering Laboratories

FRESNO 17, CALIFORNIA
Valley Foundry & Machine Works

NEW HAVEN, CONNECTICUT
Macalaster Bicknell Company

ATLANTA, GEORGIA
Southern Scientific Company

CHICAGO 44, ILLINOIS
Fred S. Hickey, Inc.

NEW ORLEANS, LOUISIANA
W. H. Curtin & Company

CAMBRIDGE 39, MASS.
Macalaster Bicknell Company

ST. LOUIS 4, MISSOURI
Stemmerich Supply Inc.

LODI, NEW JERSEY
Mooney Brothers Corporation

ALBANY 5, NEW YORK
A. J. Eckert Industrial Sales Corporation

BUFFALO 13, NEW YORK
Buffalo Apparatus Co.

ROCHESTER 3, NEW YORK
Will Corporation

HATBORO, PA.
Sentinel Glass Company

PITTSBURGH 19, PA.
Fisher Scientific Company

HOUSTON 7, TEXAS
W. H. Curtin & Company

SEATTLE 4, WASHINGTON
Scientific Supplies

TORONTO, ONTARIO, CAN.
Fisher Scientific Company, Ltd.

MONTREAL 3, QUEBEC, CAN.
Fisher Scientific Company, Ltd.

VANCOUVER, B. C., CAN.
Scientific Supplies

CORNING GLASS WORKS
Dept. EP-11, Corning, N. Y.

Please send me the information checked below:

- ☐ "PYREX brand Glass Pipe in the Process Industries." (Application experience)
- ☐ "Installation Manual."
- ☐ "PYREX brand 'Double-Tough' Glass Pipe and Fittings." (New catalog)
- ☐ I want to see a PYREX pipe representative.

Name ....

Title ....

Company ....

Street ....

City .... Zone ....

State ....

CORNING GLASS WORKS, CORNING, NEW YORK

Corning means research in Glass

(Continued from page 64)

95 • CENTRIFUGAL PUMPS. Display of centrifugal pumps featuring a new solid plastic centrifugal. Designed for mechanical seals with fluid end parts of corrosion-resistant solid plastic material. Made in 3-in. suction, 2-in. discharge only. Operates at 1,750 rev./min., capacities to 300 gal./min. and heads to 110 ft. Mission Mfg. Co. Booth C-147.

96 • FLUID MIXERS. Fluid mixer units, including special designs for research & pilot plant operations. Theme of the exhibit will be Scale-Up with data on research & pilot plant studies. Full-size unit on stream including variables and accessories. Sizes to 500 hp. Mixing Equipment Co. Booth 800.

97 • MONOMERS & POLYMERS. Three hundred monomers & polymers, many not elsewhere available. Dental monomers, cross-linking agents, monomers for polyelectrolytes, catalysts & accelerators. Consulting staff in attendance. Monomer-Polymer, Inc. Booth 73.

98 • METAL PLATE. Multi-Plate, new fabricated alloy sheet metal plate for filter presses. Corrugated-sheet drainage field combined with machined supporting frame. Adaptable to all plate & frame filters, in all sizes and alloys. Multi-Metal Wire Cloth Co., Inc. Booth 136.

99 • MIX-MULLER. Simpson LF Mix-Muller in new laboratory size. Provides laboratories & pilot plants with working duplication of production mixing. Will establish standards and/or check quality and efficiency. Pan diam. of 24 in. with components in proportion to plant size unit. National Engineering Co. Booth 410.

100 • VALVES. From Rheinhuette of Germany, heavy-duty acid & chemical valves. Made of corrosion-resistant metals — chrome, nickel, molybdenum, cupro alloys, & available with hard rubber or antimonial lead linings. Valves operate to 600 lb./sq.in. and 300°C. Neumann & Welchman. Booth C-133.

101 • LABORATORY EQUIPMENT. Laboratory equipment, plus new gyratory shaker, & five-liter fermenter of stainless steel. New Brunswick Scientific Co. Booth 626.

102 • AGITATING EQUIPMENT. Nettco Flomix, T-115 agitator drive mounted on flange support with rotating parts in operation, & the Nettco side drive will be on display. Flomix continuously mixes materials in pipe lines. The side drive is a new development in side-entering agitators. New England Tank and Tower Co. Booth 52.

103 • STEAM EQUIPMENT. Display of 24 types of traps, separators, & strainers, pressures to 1,500 lb.; also traps for air & gas. Series of valves for on-off action, cylinder control; special types for distributing, metering & alternating services. Welded high-pressure floats in variety of materials. W. H. Nicholson & Co. Booth S-82.

104 • VISCOMETERS. Recording, & recording-controlling viscometers. New control viscometer is of high sensitivity with accuracy ¼ per cent. Used in polymerization processes. Model for explosion-proof applications. Demonstration of standard viscometer measuring & recording viscosity of water at different temperatures. Norcross Corp. Booth 638.

105 • FILTERS & PUMPS. Seven filter models & Olivite acid-handling & Oliver diaphragm slurry pumps. Also the Oliver centri-clone, a combination of liquid cyclone and centrifuge for separation of solids while suspended in liquid slurry. Three sizes—10, 20 & 30 in. diam capacities to 800 gal./min. Oliver United Filters. Booth 513.

106 • AUTOMATIC BOILER. Process industries Powermaster packaged automatic boiler generating to 17,000 lb./hr. steam at pressures to 250 lb./sq.in. Also, specially designed cutaway Voriflow combination air-atomizing & oil premixing gas burner. Orr & Sembower Inc. Booth C-130.

107 • DUST CONTROL. Complete operation of two new dust collectors featuring control of industrial dust through the cloth filter. Pangborn Corp. Booth 906.

108 • TUBE FITTINGS. Standard Triple-lok flared fittings, Ferulok flareless fittings, new brass In-tru fittings & new Weld-lok fittings will be features. Available in brass, steel, stainless steel & aluminum. Parker Appliance Co. Booth 74.

109 • AIR CONDITIONING EQUIPMENT. Gear-operated jacketed plug cock; an improved relief valve & a newly designed jacketed diaphragm valve, all new at this time. These plus standard line of jacketed cocks, fittings & jacketed piping. Variety of materials, suitable for temperatures to 450°F. and 150-lb. jacket pressure. Parks-Cramer Co. Booth 727.

110 • EJECTORS - GAUGES - VALVES. Liquid level gauges & valves in regular & corrosion-resistant materials for chemical use. Gauge assemblies with adjustable mounting centers. Ejectors for vacuum processes & liquid transfer. Explosion-proof sump pumps, injectors, strainer, laboratory apparatus, plus a new item, a cycling jet pump operated by air, gas, or steam. Penberthy Injector Co. Booth 428.

111 • PNEUMATIC TRANSMITTERS. Indicating temperature, pressure, & motion pneumatic transmitters; pneumatic receiver recorders, a pneumatic controller & an electric flow receiver with high-speed integrator. Penn Industrial Instrument Corp. Booth 430.

112 • FILLING MACHINES. Fully automatic bottle & can-filling machine, pneumatic controls, requires no operator. Fills 1-oz. to 5-gal. containers by gravity, vacuum or press. Also semiautomatic machine requiring one operator, and a new semiautomatic tube-filling and closing machine which closes tube automatically with three folds in one revolution. Featured by Perl Machine Mfg. Co. Booth S-27.

114 • ION EXCHANGERS. Complete line of ion exchangers & equipment used in water conditioning, metal recovery & chemical processes. Plexiglass models of equipment. Also shown, applications other than water conditioning. Permutit Co. Booth C-63.

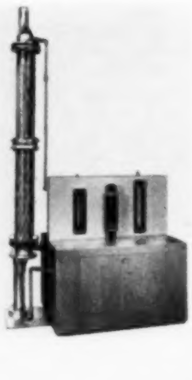
115 • CORROSIONEERING. Theme of the exhibit by Pfaudler will be Corrosioneering; engineering & fabricating services involving all materials of construction. Equipment will include heat exchanger incorporating glassed steel, for first time, on product or shell side of heat exchanger. Also new glass-lined packed column, 1000 gal. stainless steel lined high pressure dimpled jacketed kettle. Also glass lined 200-gal. standard reactor & 20 gal. stainless steel kettle incorporating hydraulic drive. The Pfaudler Co. Booth 507.

116 • GEAR PRODUCTS. Vertical & horizontal MotoReducers, worm-gear reducers, spiral bevel reducers & Limitorque motorized

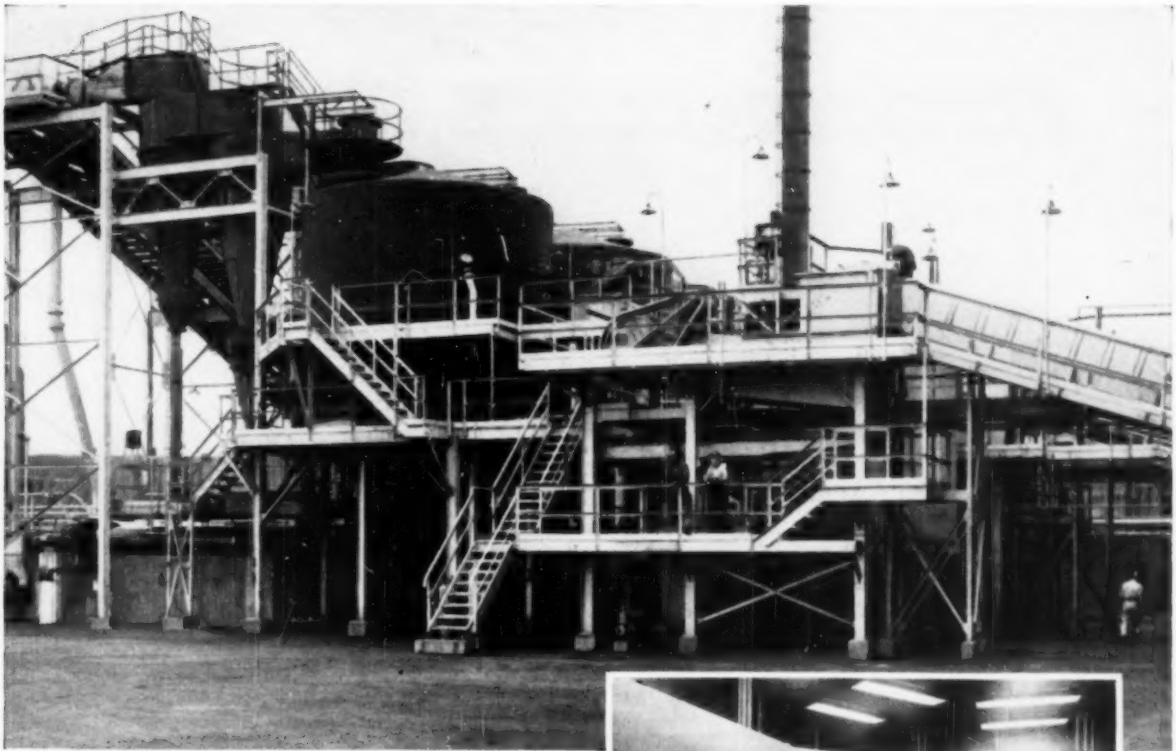
(Continued on page 72.
Use postcard on page 59)

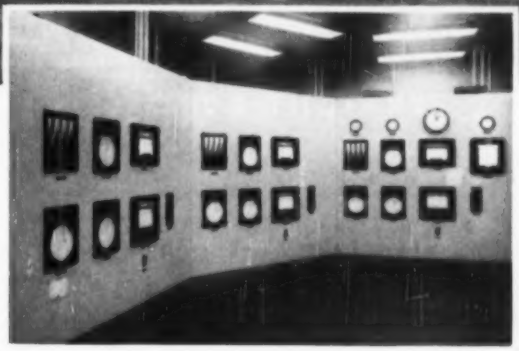
Thermo-panel plate coil. Dean Products. ▼

U. S. Stoneware packed glass tower. ▶



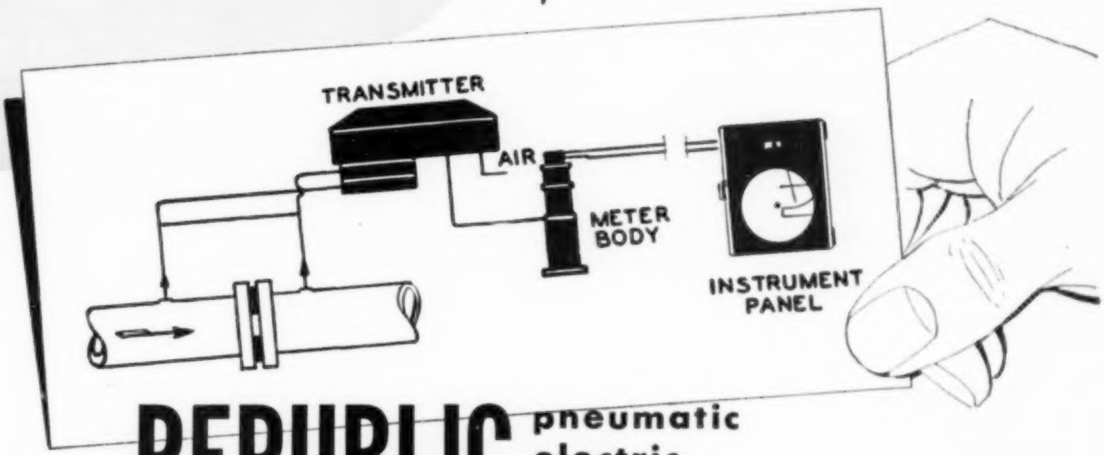
▲
Data service is the monthly feature in Chemical Engineering Progress. Use it to keep up to date with what manufacturers are producing and offering to the chemical engineer.





DO YOU HAVE THESE METERING PROBLEMS?

TOXIC OR FLAMMABLE FLUIDS
CORROSIVE FLUIDS
DIRTY FLUIDS
VISCOUS LIQUIDS
WIDELY FLUCTUATING FLOW



REPUBLIC pneumatic electric metering system

offers a practical solution to ***DIFFICULT FLOW MEASUREMENTS***

RESTRICTS DANGEROUS FLUIDS . . .
to short lead lines and small measuring chamber in pneumatic transmitter—keeps dangerous or high pressure fluids out of control rooms and mercury-type meter bodies.

CORROSION RESISTANT MATERIALS . . .
can be furnished for measuring chamber to meet requirements of almost any fluid. Corrosive fluids do not come in contact with any other part of meter.

LITTLE MOVEMENT OF LINE FLUID . . .
in lead lines and measuring chamber is required for full range. Dirt is not drawn in to clog meter and cause failure or inaccuracies.

LINE FLUID AND MEASURING CHAMBER AT SAME TEMPERATURE . . .
When measuring hot liquids which are very viscous at room temperature, transmitter may be mounted on flow line to keep temperature of liquid in measuring chamber and flow line the same.

FAST ACTING . . .
meter body does not require large movements of mercury or oil—follows all flow, no matter how erratic or fluctuating.

OTHER ADVANTAGES . . .

ELECTRIC TRANSMISSION
Flow information can be sent any reasonable distance. Electric meter body extracts square root from flow differential measurement, permitting use of uniformly graduated scales and charts.

CONTINUOUS INTEGRATION . . .
made possible by the exclusive Republic electric integrator aids in accounting and control of expensive fluids.

REMOTE READING INSTRUMENTS . . .
which include recorders, integrators and indicators, can be mounted separately or together, as desired.

WANT MORE INFORMATION?
A new bulletin describing the Pneumatic Electric Flow Meter and its applications is available at no cost or obligation. Send for Bulletin 704.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

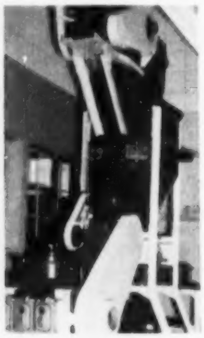
(Continued from page 68)

valve operator. Philadelphia Gear Works. Booth 33.

117 • PHOTOELECTRIC INSTRUMENTS. Colorimeters, electronic photometers, multiplier photometers, densitometers & *pH* meters being shown. Also new instruments; a densitometer for paper electrophoresis; portable *pH* meter and a line-operatd *pH* meter. Photovolt Corp. Booth C-37.

118 • WEIGHING MACHINERY. Display of packaged & bottled goods illustrating operation of weighing machinery. Also new, the Pneumatron weighing machine for free flowing material. Weighing head made up of cantilever beam assembly and air jet control. Equipped for either single or double stream weighing. Top weighing speed 90 units/min. on 4-scale, 45 units/min. on 2-scale. Pneumatic Scale Corp., Ltd. Booth 114.

119 • GRINDING MACHINERY. Rotary Airlock feeder available in 8-, 10-, 12-in. units. Design features outboard bearings of the sealed, self-aligning cartridge type, with complete lubrication system. Double dust seals where shaft extends through housing. Three other machines on display. Prater Pulverizer Co. Booth 340.



Circular-bin-discharger and Redler conveyor-elevator model. Stephens-Adamson.

120 • CHEMICAL FEED PUMP. Chemical solution feed pump for chlorinating drinking water, swimming pools & industrial wastes. Also for the fluoridation of municipal water. Feeds chemical solutions in direct proportion to varying main line flows. Precision Machine Co. Booth C-109.

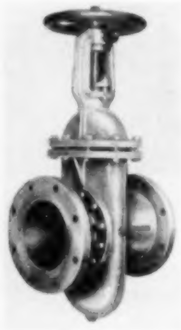
121 • DISPERSATOR DRIVE UNITS. Announced by Premier, dispersator drive units for beam or channel mounting with open tanks. Another series for flange mounting-sealed system operation. Units designed to operate in the 30 to 300 gal. batch range. Premier Mill Corp. Booth C-14.

122 • FREEZE-DRYER. Continuous freeze-drying system utilizing infrared radiation in selected wavelengths & a spray-drying system. Also, new standard truck tray & tray dryers; application of preforming feeding devices; & continuous conveyor dryers for handling bulk chemicals. Proctor & Schwartz, Inc. Booth 60.

123 • PLANT STREAM ANALYZER. Continuous, automatic analysis of gas in a flowing stream to control component concentration & purity of mixtures. An infrared, absorbing, nondispersive instrument using a blind pneumatic transmitter & miniature recorder. Designed for installation at sampling point. Process Controls Division Baird Associates, Inc. Booth 63.

124 • PULVERIZERS & FEEDERS. Impact pulverizers, Pulva-Sizers, & Com-Bin stainless steel feeders. Pulva-Sizers used for fine grinding, granulating or wet milling. Units will be demonstrated on sticky, mastic material to show product handling. Pulva Corp. Booth 328-330.

125 • MATERIALS HANDLING. Working model of high suction pneumatic system for conveying granular & powdered materials by fluid energy. For materials transport from box car or truck to storage bin, or from processing to storage. Also, Mikro-Atomizers, Mikro-Pulverizers, & Mikro-Collectors. Pulverizing Machinery Co. Booth C-30.



Rheinhuette heavy-duty acid and chemical valves in Neumann & Welchman exhibit.

126 • CORROSION TREATMENT. Metal parts, castings, sheet metal fabrications, fans, gratings, etc. dipped in polyvinyl chloride pastes, forming a fused-in-place, nonstrippable coating, 0.030 to 0.150 in. thick or more. For resistance to mineral acids, bases, & salts. Quelcor, Inc. Booth S-113.

127 • TITANIUM. Enduro titanium & stainless steel. Titanium is available commercially either pure or alloy. Commercial forms will be shown. Metallurgical staff in attendance. Republic Steel Corp. Booth 535-539.

128 • PLUG VALVES. Display of displacement meters for measuring liquids, hot water, gasoline, solvents & other chemicals. Also featured will be Nordstrom Hyperseal valves for high-pressure gas services in the petrochemical industry. Pressures to 10,000 lb./sq.in. New lubricants & accessories, alloy valves for corrosive & abrasive slurry services. Rockwell Mfg. Co. Booth 617.

129 • MIXING AND GRINDING MACHINERY. Feature display of high-speed three-roll mill, a double-arm kneader, & a newly designed 80-gal. change can mixer featuring double planetary stirrer action. Charles Ross & Son Co. Booth 447.

130 • REVOLVING JOINTS. Show of revolving joints to bring heating medium, steam, air, water, to moving equipment. Rotation takes place on flat face of a carbon seal, flexing on a ball sphere. Sizes 1/2 to 5 in., capable of handling 250 lb./sq.in. steam from −100°F. to +500°F. Rotherm Engineering Co., Inc. Booth C-143.

131 • AIR COMPRESSOR. A two-stage centrifugal air compressor, 1000 cu. ft./min. at 125 lb./sq.in gauge atmospheric pressure. Eddy current clutch inserted between motor and compressor as unloading device when system requires no air. Also a recycle single stage centrifugal compressor. Static pressure 1 atm. abs. to 600 lb./sq.in.gauge. Sawyer Bailey Corp. Booth C-62.

▲
For most of the equipment described here, the manufacturers have available complete bulletins and catalogs.

132 • PROCESSING EQUIPMENT. Display of fluid processing equipment. Batch heating units for oils, resins; gradiation heater for liquid chemicals and petroleum; laboratory separators operating on emulsions met in solvent extraction; micro-filters; liqui-jectors; vapesorbers, dehydrators. Selas Corporation of America. Booth 62.

133 • FILTER PRESS. Pictorial display of filter press types, principles of operation, & variations of equipment for processing operations. Also an actual filter press equipped with a hydraulic closing mechanism & a cutaway model of a diaphragm pump. T. Shriver & Co. Booth 17.

134 • SCREENS. Tray-type screen for fine sizing or dewatering of any liquid from any product. Also a positive vertical compacting unit. Simplicity Engineering Co. Booth 822.

135 • DUST FILTERS. Displayed for the first time to the chemical industry, Dynaclone dust filter, cloth-bag-type dust filter. Operates in conjunction with mixers, separators, conveyors, pulverizers. Continuous cleaning of filter bags by reverse air flow, no mechanical vibration of bags. W. W. Sly Mfg. Co. Booth 713.

(Continued on page 74.
Use postcard on page 59)

(Continued from page 72)

136 • RETRACTABLE TANK FILTER. New, heavy-duty retractable tank filter, available in capacities 100 to 2,000 sq.ft. of filter surface. Cleaned by jet spray washoff, backwashing, combination of both or by hand. Displayed will be a 1,000-ft. unit. Sparkler Mfg. Co. Booth C-54.

137 • CONVEYING MACHINERY. Model of a circular bin discharger & a Redler conveyor elevator. Bin and feed dischargers prevent arching & clogging, discharge bulk materials from bins & silos. Three types, either free or measured discharge. Conveyor elevators available to convey in any direction. Stephens-Adamson Mfg. Co. Booth 239.

138 • VACUUM FURNACES & DRYERS. Laboratory-size rotary vacuum dryer & a full-size model of a Microvac pump are in exhibit of F. J. Stokes Machine Co. Booth 910.

139 • DRAIN VALVE. Drain Valve designed to prevent clogging. In closed position, piston is forced into vessel which pushes aside material which may clog. No gland or stuffing box. Piston moves through two resilient rings on which tension is maintained by compression nuts. Rings replaced without removing valve from service. Strahman Valves, Inc. Booth S-106.

140 • AIR CENTRIFUGE. For continuous dust removal & particle recovery in the small micron range, an air centrifuge using a new impelled centrifuge. Non-varying results over wide range of temperature and humidity. For plant air system involving grinders, pulverizers, dryers; also for sticky & non-free flowing dust. Superior Grain Separator Co. Booth S-34.

141 • LOW-TEMPERATURE PROCESSING. Low-temperature equipment, as low as −100°F. for chemical processing. Air continuously delivered from humidity conditioning unit to low temperature without frost formation on refrigerator coils. Operate independently of room or outside air conditions. Surface Combustion Corp. Booth 54.

142 • CONTROL INSTRUMENTS. An animated exhibit featuring instruments for measurement & control of temperature, pressure, flow, liquid level, density, load, & time. Transet plug-in instruments shown on 7 × 5-ft. board. Taylor Instrument Co. Booth 36.

143 • MICRO PUMP. Micro pump for quantities 0.001 ml. to 0.1 ml./stroke; adjustable to within 0.0001 ml.; reproduceable to within 0.014% at any setting. Also automatic fraction collector, a time-operated collection apparatus with accessories for counting individual drop of fluid as control. Technicon Chromatography Corp. Booth 616.

144 • MATERIALS HANDLING EQUIPMENT. Exhibit of new bulk material-handling system for interplant shipment or in-plant operations. Includes air-tight containers, dust-tight discharge equipment with batching, weighing &

(Continued on page 76.
Use postcard on page 59)

(Continued from page 74)

blending when desired & dust tight filling. Tote System, Inc. Booth C-128.

145 • HEAT PROCESSING. Models of electric furnaces, ovens, kettles & kettle jackets, plus methods of heating vessels, autoclaves, etc. Heating elements, strip, cartridge, immersion, & technique of heating valves to prevent freezing, in display of Trent, Inc. Booth 803.

146 • ELECTRICAL MOTORS. Industrial electrical motors, including the Uniclosed horizontal motor, Varidrive variable speed motor. Synchrogear motor, & totally enclosed and explosion-proof motors. Animated panel demonstrates Varidrive speed changer. Motors from 1/4 to 400 hp. U. S. Electrical Motors, Inc. Booth 740.

147 • TOWER PACKING. Packed glass tower showing range of pressure drop & flooding limits of Intalox saddle packing; newly designed for increased surface area & wettable surface. Also a new porcelain body which extends the characteristics of laboratory porcelains into the industrial field. New fume washing tower, available in two sizes, capacities of 750 to 1,500 cu.ft./min. U. S. Stoneware Co. Booths 10-12-14.

148 • PUMPS & VALVES. A display of Flex-i-liner rotary pumps, natural and Buna N hard-rubber centrifugals, valves, pipe, fittings, polyvinyl chloride centrifugals, & polyethylene valves. Pumps have no metallic contact with fluid, & liner eliminates shaft seals, stuffing boxes, check valves, & gasket. Vanton Pump & Equipment Corp. Booth 715.

149 • VALVES, FITTINGS, & FLANGES. Constructed of drop forged steel, resistant to corrosion and erosion, & designed for high-pressure and high-temperature services. Featured will be union bonnet, bolted gland & bonnet, globe valves for 800-lb. service. Also a sectioned heat-exchanger unit of two-shell pass type with positive-seal baffle & ell bolt for floating assembly sheet. Henry Vogt Machine Co. Booth 56.

150 • INDUSTRIAL CONTROL CENTERS. Flexible industrial control centers providing removal and exchange of individual components. Contain line starters, air circuit breakers, & other devices. Also chemical motors, motor controls. Westinghouse Electric Corp. Booth 200.

151 • TUBING. Plain and finned tubing of electrically resistance welded steel, copper, & copper base alloy for aluminum heat exchangers. Also U-bend expendable box-type shipping pallet and other tubular products. Wolverine Tube Division, Calumet & Hecla, Inc. Booths C-134—C-136.

152 • PUMPS. Centrifugal pumps constructed of cast iron & plastic, Worthite gate valves & industrial mixers. Centrifugal pump newly designed, features interchangeability of parts. Pump uses four frames accommodating 107 different liquid end sizes for six different types of pumps. Capacities 12,000 gal./min. & heads to 500 ft. Worthington Corp. Booth 848.

153 • AUTOMATIC ICE MAKER. Flakice automatic ice maker & photographic transparencies of ammonia absorption system. Cutaway view & parts of centrifugal compressor. York Corp. Booth 646.

LIST OF EXHIBITORS

24TH EXPOSITION OF CHEMICAL INDUSTRIES

November 30—December 5, 1953

	Booth No.
A	
Ace Glass, Inc., *Vineland, N. J.*	710
Adams Co., Inc., R. P., *225 East Park Drive, Buffalo 17, N. Y.*	939
Admiral Tool & Die Co., Inc., *45-10 Vernon Blvd., Long Island City 1, N. Y.*	339
Aetna Scientific Co., *Second & Spring Sts., Everett 49, Mass.*	C-28
Airetool Mfg. Co., The, *302 S. Center St., Springfield 99, Ohio*	S-74
Airmatic Tool Co., *6607 Marsden St., P.O. Box 8943, Philadelphia 35, Pa.*	C-138 & C-140
Alabama State Planning Board, *102 Church St., Montgomery 4, Ala.*	C-148
Alberene Stone Corporation of Virginia, *419 Fourth Ave., New York 16, N. Y.*	533
Allegheny Ludlum Steel Corp., *2020 Oliver Bldg., Pittsburgh 22, Pa.*	28
Allen-Sherman-Hoff Pump Co., The, *259 E. Lancaster Ave., Wynnewood, Pa.*	C-119
Allis-Chalmers Mfg. Co., *Milwaukee 1, Wis.*	508
Allis Co., The Louis, *Milwaukee 7, Wis.*	907
Alloy Steel Products Co., *Linden, N. J.*	35
Aloe Scientific, Division of The A. S. Aloe Co., *5655 Kingsbury, St. Louis 12, Mo.*	53
Alpha Plastics, Inc., *14 Northfield Road, West Orange, N. J.*	S-108
Alsop Engineering Corp., *Milldale, Conn.*	110
Aluminum Company of America, *Pittsburgh 19, Pa.*	233-235
American Air Filter Co., Inc., *1st & Central Aves., Louisville 8, Ky.*	150 & 250
American Chemical Society, *1155 Sixteenth St. N. W., Washington 6, D. C.*	1
American Chemical Society News Service, *60 East 42nd Street, New York 17, N. Y.*	71
American Gas Furnace Co., *Elizabeth, 8, N. J.*	C-144
American Hard Rubber Co., *93 Worth St., New York 13, N. Y.*	13
American Instrument Co., Inc., *8030-8050 Georgia Ave., Silver Spring, Md.*	736
American Machine & Foundry Co., *511 Fifth Ave., New York 17, N. Y.*	C-150
American Machine and Metals, Inc., Tolhurst Centrifugals and Niagara Filter Div., *East Moline, Ill.*	802-806-808
American Monomer Corp., *511 Lancaster St., Leominster, Mass.*	73
American Optical Co., Instrument Div., *Buffalo 15, N. Y.*	348
American Platinum Works, The, *231 New Jersey Railroad Ave., Newark 5, N. J.*	C-21
American Polymer Corp., *101 Foster St., Peabody, Mass.*	73
American Resinous Chemicals Corp., *103 Foster St., Peabody, Mass.*	73
American Sterilizer Co., *Erie 6, Pa.*	732
American Tool & Machine Co., *30 Church St., New York 7, N. Y.*	826
American Water Softener Co., *Fourth and Lehigh Aves., Philadelphia 33, Pa.*	S-64
American Wheelabrator & Equipment Corp., *Mishawaka, Ind.*	133
Amersil Co., Inc., *1471 Chestnut Ave., Hillside, N. J.*	C-19
Ampco Metal, Inc., *1745 S. 38 St., Milwaukee 46, Wis.*	325
Analytical Chemistry, *330 West 42nd St., New York 36, N. Y.*	71
Anderson Co., The V. D., *1935 West 96th St., Cleveland 2, Ohio*	C-129
Andrews-Knapp Construction Co., Inc., *23-15 Borden Ave., Long Island City 1, N. Y.*	19
Angel & Co., Inc., H. Reeve, *52 Duane St., New York 7, N. Y.*	344
Ansul Chemical Co., *Marinette, Wis.*	521
Anthracite Equipment Corp., *Anthracite Institute Bldg., Wilkes-Barre, Pa.*	C-117
Arco Rubber Processors, *4033 Homestead Road, Houston, Tex.*	706
Aries & Associates, R. S., *270 Park Ave., New York, N. Y.*	S-5
Arrow Hart & Hegeman Electric Co., The,	

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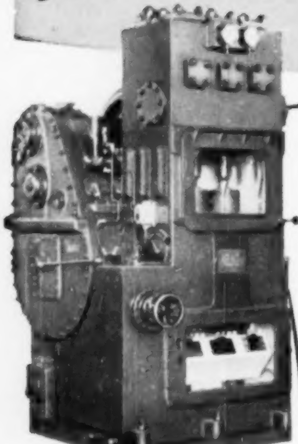
103 Hawthorn St., Hartford 6, Conn. . . . 45
Artisan Metal Products, Inc., 73 Pond St., Waltham 54, Mass. . . . 320
Associated Cooperage Industries of America, Inc., The, 408 Olive St., St. Louis 2, Mo. . . . 818
Atlas Mineral Products Co., The, Mertztown, Pa. . . . 429
Atlas Powder Co., Wilmington 99, Del. . . . 302-304-401
Attapulgus Minerals & Chemicals Corp., 210 W. Washington Sq., Philadelphia 5, Pa. . . . S-57
Aurora Pump Co., subsidiary of The New York Air Brake Co., Aurora, Ill. . . . 950
Autoclave Engineers, Inc., 860 E. 19th St., Erie, Pa. . . . 434
Automatic Switch Co., 391 Lakeside Ave., Orange, N. J. . . . C-116
Automotive Rubber Co., Inc., 12550 Beech Road, Detroit 28, Mich. . . . 706

B

B-I-F Industries, 345 Harris Ave., P.O. Box 1342, Providence 1, R. I. . . . 202-204
Bailey Meter Co., 1050 Ivanhoe Road, Cleveland 10, Ohio . . . 30
Baird Associates, Inc., Process Controls Div., 11 University Road, Cambridge 38, Mass. . . . 63
Baker & Co., Inc., 113 Astor St., Newark 5, N. J. . . . C-17
Baker Perkins Inc., Saginaw, Mich. . . . 540-544
Barco Mfg. Co., Barrington, Ill. . . . C-38
Barnebey-Cheney Co., Eight and Cassady Aves., Columbus, Ohio . . . S-1
Barnstead Still & Sterilizer Co., 2 Lanesville Terrace, Forest Hills, Boston 31, Mass. . . . 636
Barrett-Cravens Co., 4613 S. Western Blvd., Chicago 9, Ill. . . . 634-733
Bart Manufacturing Corp., 229 Main St., Belleville 9, N. J. . . . S-22
Bart-Messing Corp., 229 Main St., Belleville 9, N. J. . . . S-22
Bartlett & Snow Co., The C. O., 6200 Harvard Ave., Cleveland 5, Ohio . . . 209
Bean Div., John, Food Machinery & Chemical Corp., Box 840, Lansing 4, Mich. . . . 322
Beckman Instruments, Inc., South Pasadena, Calif. . . . 20
Belgian Electric Sales Corp., 40 East 49th St., New York 17, N. Y. . . . 625
Bemis Bros. Bag Co., 408 Pine St., St. Louis 2, Mo. . . . 15
Berger Mfg. Div., Republic Steel Corp., Canton, Ohio . . . 535-539
Bersworth Chemical Co., Framingham, Mass. 813
Bethlehem Apparatus Co., Inc., Front and Depot Sts., Hellertown, Pa. . . . 225
Bird Machine Co., South Walpole, Mass. . . . 332-431
Bishop & Co. Platinum Works, J., Malvern, Pa. . . . 809
Black Products Co., 135th St. & Calumet Ave., Chicago 27, Ill. . . . S-65
Black, Sivalls & Bryson, Inc., 7500 E. Twelfth St., Kansas City 26, Mo. . . . 214
Blackburn-Smith Mfg. Co., 95 River St., Hoboken, N. J. . . . S-84, S-86
Blaw-Knox Co., Pittsburgh, Pa. . . . 103
Blaw-Knox Construction Co., Chemical Plants Div., Pittsburgh, Pa. . . . 103
Blaw-Knox Div. of Blaw-Knox Co., Pittsburgh, Pa. . . . 103
Blickman, Inc., S., Weehawken, N. J. . . . 407
Bogue Electric Mfg. Co., 52 Iowa Ave., Paterson 3, N. J. . . . 421
Bolt & Nut Div., Republic Steel Corp., Cleveland, Ohio . . . 535-539

(Continued on page 82)

There's an ALDRICH Pump to meet your chemical pumping need...



▲ Aldrich-Groff "POWR-SAVR" Controllable Capacity Pump.

APPLICATIONS

Among many liquids handled by Aldrich Pumps are: caustic solutions, fatty acids, nitric acid, acetic acid, aqua ammonia, anhydrous ammonia, as well as liquids encountered in the petroleum refining, petroleum chemical, and other industries.

For automatically controlled delivery

This calls for an *Aldrich-Groff "POWR-SAVR"*—a variable stroke triplex pump which controls delivery from 0 to 100% capacity at constant pump and motor speed. Control can be accomplished from any remote point, manually or automatically. Power consumption is almost directly proportional to demand. Units handle any free-flowing liquid at discharge pressures from 300 to 15,000 psi and are available in six sizes: from 2" to 6" stroke and from 5 to 125 bhp. Request Data Sheet 65.

For high pressure at small volume

Specify the *Aldrich-Lytle Hydro-Pneumatic Unit.* This pump is self-contained, uses normal plant air supply as the power medium, and provides high pressures (up to 20,000 psi) at small volume. Request Data Sheet 69A.

For medium to high pressure service

Here, several types of constant stroke pumps are available—depending upon the service involved. You may need the Inverted Vertical Triplex (Data Sheet 66), the Vertical Triplex (Data Sheet 26), or the Direct Flow Triplex or Multiplex Pump (Data Sheets 64, 64B).

From our experience in building pumps for the chemical industry, we can—from our engineering and service files—frequently make specific recommendations to meet your chemical pumping needs . . . whether your problem involves corrosion, high viscosity or high pressure.

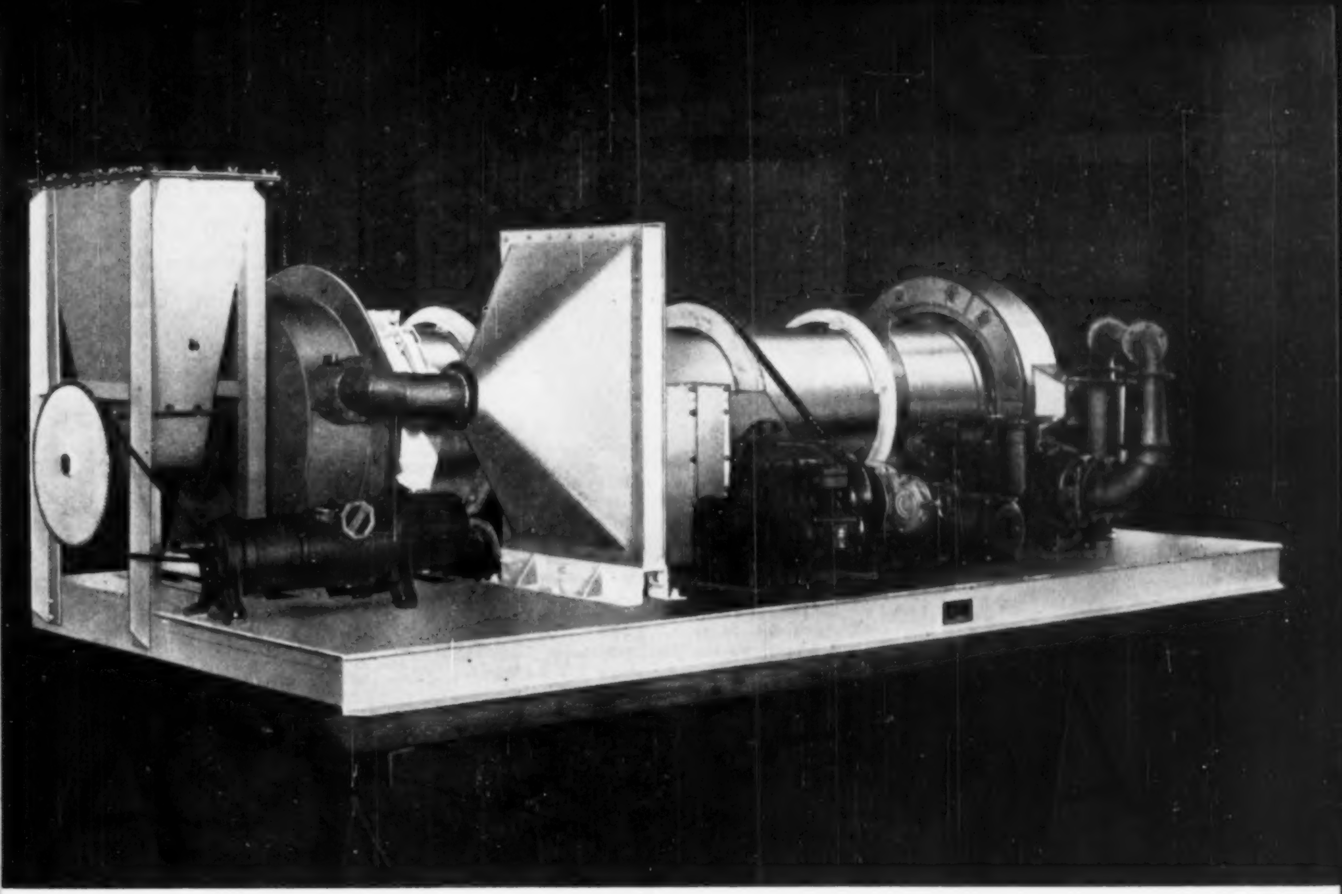
Any or all of the above Data Sheets are available on request.

Aldrich Accumulators are also available to meet your displacement requirements. For information on hydro-pneumatic and weight-loaded types, request Data Sheets 29, 29A. ▶

THE ALDRICH PUMP COMPANY ...*Originators of the Direct Flow Pump*

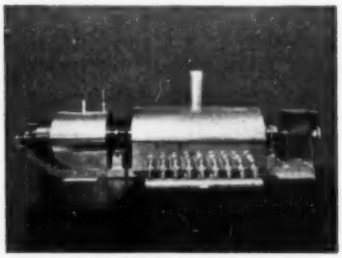
20 GORDON STREET • ALLENTOWN, PENNSYLVANIA

Representatives: Birmingham • Bolivar, N. Y. • Boston • Buffalo • Chicago • Cincinnati • Cleveland • Denver • Detroit • Duluth • Houston • Jacksonville • Los Angeles • New York • Omaha • Philadelphia • Pittsburgh • Portland, Ore. • Richmond, Va. • St. Louis • San Francisco • Seattle • Spokane, Wash. • Syracuse • Tulsa



stainless steel *Anti-Biotic Dryer*

Rotary Cooler with Continuous Spiral Flight Permitting the Rate of Cooling to be Controlled by the Speed of Shell Rotation.



Experimental Calciner, Determines the Preferred Operating Conditions Preliminary to Building Full Size Plant Equipment.

. . . Specially designed unit removes an organic solvent from a newly developed anti-biotic— avoids product contamination.

● The drying cylinder with ground and sand blasted welds, and flights that lift the material and cascade it down through the heated air stream, present a smooth interior surface, without corners, permitting the entire interior surface to be cleaned thoroughly and quickly. Feed hopper, variable speed screw feeder, heating coils, air blower, air sterilizer, exhaust fan and cyclone dust collector are mounted on the same frame to insure permanent alignment of all parts and efficient trouble-free operation. This unit is an example of Bartlett-Snow's ability to design and build equipment that meets the most exacting requirements. Let us work with you on your next drying problem!

DESIGNERS ENGINEERS **BARTLETT - SNOW** CLEVELAND 5, OHIO FABRICATORS ERECTORS

Dryers · Coolers · Calciners · Kilns

"Builders of Equipment for People You Know"

LIST OF EXHIBITORS

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Bowen Engineering, Inc., North Branch, N. J. C-27
Bowser, Inc., 1302 E. Creighton Ave., Fort Wayne 2, Ind. 234
Brabender Corp., Rochelle Park, N. J. C-35
Bramley Machinery Corp., 880 River Road, Edgewater, N. J. 723-725
Branson Instruments, Inc., 430 Fairfield Ave., Stamford, Conn. 847
Brinkmann & Co., C. A., 378-380 Great Neck Road, Great Neck, N. Y. C-36
Brooks Rotameter Co., Lansdale, Pa. 210
Brosites Machine Co., Inc., 50 Church St., New York, N. Y. S-92
Brown Co., Berlin, N. H. 222
Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio 633
Buffalo Apparatus Corp., Buffalo, N. Y. 734
Buffalo Meter Co., 2917 Main St., Buffalo 14, N. Y. 442
Buffalo Scale Co., Inc., 46 Letchworth St., Buffalo 13, N. Y. 817
Buflovak Equipment, Div. of Blaw-Knox Co., Buffalo 11, N. Y. 103
Builders-Providence, Inc., 345 Harris Ave., P.O. Box 1342, Providence 1, R. I. 202-204
Byron Jackson Co., P.O. Box 2017 Terminal Annex, Los Angeles 54, Calif. C-118

C

C-O-Two Fire Equipment Co., U. S. Highway 1, Newark 1, N. J. S-90
Cambridge Instrument Co., Inc., Grand Central Terminal, New York 17, N. Y. 926
Carboline Co., 331 Thornton Ave., St. Louis 19, Mo. 427
Carpenter Steel Co., The, Alloy Tube Div., Union, N. J. 414
Carrier Conveyor Corp., Frankfort Ave. at Clifton Ave., Louisville 6, Ky. 117
Carver, Inc., Fred S., 1 Chatham Road, Summit, N. J. 8
Central Scientific Co., 1700 Irving Park Road, Chicago 13, Ill. 606
Centrico, Inc., 75 West Forest Ave., Englewood, N. J. 2
Chain Belt Co., Milwaukee 1, Wis. S-6
Chamberlain Engineering Corp., Akron, Ohio 10-12-14
Chemical Abstracts, 330 West 42nd St., New York 36, N. Y. 71
Chemical Corp., The, 54 Waltham Ave., Springfield 9, Mass. C-120
Chemical Engineering, 330 West 42nd St., New York 36, N. Y. 501
Chemical Engineering Catalog, 330 West 42nd St., New York 36, N. Y. 71
Chemical and Engineering News, 330 West 42nd St., New York 36, N. Y. 71
Chemical Engineering Progress, 120 East 41st St., New York 17, N. Y. 828
Chemical and Industrial Corp., The, 256 McCullough St., Cincinnati 26, Ohio S-7
Chemical Materials Catalog, 330 West 42nd St., New York 36, N. Y. 71
Chemical Plants Div. of Blaw-Knox Construction Co., Pittsburgh, Pa. 103
Chemical Processing, 111 E. Delaware Place, Chicago 11, Ill. 610
Chemical Week, 330 West 42nd St., New York 36, N. Y. 501
Chemicolloid Laboratories, Inc., 30 Church St., New York 7, N. Y. 43
Chemiquip Co., 460 W. Broadway, New York 12, N. Y. S-53
Chempump Corp., 1300 E. Mermaid Lane, Chestnut Hill, Philadelphia 18, Pa. 317
Chicago Bridge & Iron Co., 332 So. Michigan Ave., Chicago 4, Ill. 807
Chiksan Co., Brea, Calif. 607
Cleveland Mixer Co., The, 3236 West 33rd St., Cleveland 9, Ohio C-141
Cleveland Vibrator Co., The, 2828 Clinton Ave. West, Cleveland 13, Ohio S-112
Cleveland Worm & Gear Co., The, 3249-59 E. 80th St., Cleveland 4, Ohio 72
Colton Co., Arthur, Div. of Snyder Tool & Engineering Co., 3400 E. Lafayette Ave., Detroit 7, Mich. 301
Combustion Engineering, Inc., 200 Madison Ave., New York 16, N. Y. 67
Combustion Engineering, Inc., Raymond Div., 1315 N. Branch St., Chicago 22, Ill. 68
Commercial Filters Corp., 2 Main St., Melrose 76, Mass. 310
Commercial Solvents Corp., 260 Madison Ave., New York 16, N. Y. 51
Condenser Service & Engineering Co., 95 River St., Hoboken, N. J. S-84, S-86
Conkey Filter Unit, General American Transportation Corp., 10 E. 49th St., New York 17, N. Y. 42-44
Conneaut Rubber and Plastics Corp., Conneaut, Ohio 10-12-14
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa. 439-441
Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 8, Calif. 335
Consolidated Machine Corp., 39 Sudbury St., Boston 14, Mass. S-67
Continental Can Co., Inc., Fibre Drum Div., 100 East 42nd St., New York 17, N. Y. 29
Continental-Diamond Fibre Co., Newark, Del. 534
Control Engineering Corp., 560 Providence Highway, Norwood, Mass. 821
Cooper Alloy Foundry Co., The, Hillside 5, N. J. 602
Corning Glass Works, Corning, N. Y. 48
Cowles Co., The, Cayuga, N. Y. C-22
Crane Co., 836 S. Michigan Ave., Chicago 5, Ill. 139
Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill. S-107
Croll-Reynolds Co., Inc., 751 Central Ave., Westfield, N. J. 236
Croll-Reynolds Engineering Co., Inc., 17 John St., New York 38, N. Y. .... 236 & 437
Crucible Steel Company of America, P.O. Box 88, Pittsburgh 30, Pa. 832-931
Culvert Div., Republic Steel Corp., Cleveland, Ohio 535-539
Cuno Engineering Corporation, The, Meriden, Conn. 440
Cyclone Fence, American Steel & Wire Division, United States Steel Corporation, Waukegan, Ill. 518-522

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Darco Dept., Atlas Powder Co., 60 East 42nd St., New York 17, N. Y. 302-304-401
Davenport Machine & Foundry Co., 1628-66 West Fourth St., Davenport, Iowa 443
Davis Instruments, 47 Halleck St., Newark 4, N. J. S-52
Day Co., The, 810 Third Ave. N. E., Minneapolis 13, Minn. 5
Day Co. Inc., The J. H., Cincinnati 22, Ohio 921-925
Dean Products, Inc., 1042 Dean St., Brooklyn 16, N. Y. S-111
Delanium Carbon Corp., 18 East 48th St., New York 17, N. Y. 648
DeLaval Separator Co., The, Poughkeepsie, N. Y. C-16
Delaware Valley Engineering Co., 3326 Lancaster Ave., Philadelphia 4, Pa. S-50, S-52, S-54
Despatch Oven Co., 619 S.E. 8th St., Minneapolis 14, Minn. 140
DeZurik Shower Co., Sartell, Minn. 426
Dietert Co., Harry W., 9330 Roselawn Ave., Detroit 4, Mich. 639
Dings Magnetic Separator Co., 4740 W. Electric Ave., Milwaukee 14, Wis. 825

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Dorr Co., The, Barry Place, Stamford, Conn. 514
Downingtown Iron Works, Div. of Pressed Steel Tank Co., Downingtown, Pa. 714
Dracco Corp., Harvard Ave. & E. 116th St., Cleveland 5, Ohio C-24
Dudco Div., The New York Air Brake Co., 1796 E. Nine Mile Road, Detroit, Mich. 950
Dumatic Industries, Twelfth St. below Jefferson, Philadelphia 22, Pa. C-40
Durametallic Corp., 2104 Factory St., Kalamazoo 24 F, Mich. 223
Duriron Co., Inc., The, P. O. Box 1019, Dayton 1, Ohio 58-59
Dustex Corp., P. O. Box 2520, 1758 Walden Ave., Buffalo 25, N. Y. 415

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Eastern Industries Inc., 296 Elm St., P. O. Box 1575, New Haven 6, Conn. 314-316
Eastern Stainless Steel Corp., Baltimore 3, Md. 126
Eaton-Dikeman Co., The, Mount Holly Springs, Pa. 425
Eclipse Fuel Engineering Co., Rockford, Ill. 747
Eco Engineering Co., Div. of Economy Faucet Co., Inc., 12 New York Ave., Newark 1, N. J. 647
Eiche & Associates Inc., R. J., 30 Church St., New York 7, N. Y. .... C-123 & C-127
Eimco Corp., The, 634-666 South Fourth West St., Salt Lake City 10, Utah .. C-9
Electric Hotpack Co. Inc., The, Cottman Ave. at Melrose St., Philadelphia 35, Pa. 933
Electric Steel Foundry Co., 2141 N. W. 25th Ave., Portland 10, Ore. .. C-160 & C-162
Elliott Co., Jeannette, Pa. S-10
Emery Industries, Inc., 2504 Carew Tower, Cincinnati 2, Ohio 718
Emsco Mfg. Co., 6811 South Alameda St., Los Angeles, Calif. C-127
Energy Control Co., Inc., 5 Beekman St., New York 38, N. Y. 422-424-426-428 430-432
Entoleter Div., The Safety Car Heating & Lighting Co., Inc., P. O. Box 904, New Haven 4, Conn. 703
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Ess Instrument Co., Div. of Ess Specialty Corp., 96 S. Washington Ave., Bergenfield, N. J. 424
Exact Weight Scale Co., The, 944 W. Fifth Ave., Columbus 8, Ohio C-12

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Falstrom Co., Falstrom Court, Passaic, N. J. 75
Farris Engineering Corp., Palisades Park, N. J. C-55
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Farris Stacon Corp., Palisades Park, N. J. .. C-55
Farval Corp., The, 3249-59 E. 80th St., Cleveland 4, Ohio 72
Federal Refractories Corp., Mineral City, Ohio 10-12-14
Fenwal, Inc., Ashland, Mass. 909
Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 North 4th St., Philadelphia 33, Pa. 448
Filtration Engineers Inc., 155 Oraton St., Newark 4, N. J. 3
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Fischer & Porter Co., Hatboro, Pa. 948

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Fletcher Works, Inc., Glenwood Ave. & Second St., Philadelphia 40, Pa. 102
Flexitallic Gasket Co., Eighth and Bailey Sts., Camden 2, N. J. 631
Flexonics Corp., Maywood, Ill. 643
Flexrock Co., Mechanical Packing Div., 36th & Filbert Sts., Philadelphia 4, Pa. S-17
Food Engineering, 330 West 42nd St., New York 36, N. Y. 501
Food Machinery & Chemical Corp. John Bean Div., Box 840, Lansing 4, Mich... 322
Peerless Pump Div., 301 West Ave., Twenty-six, Los Angeles 31, Calif. 805
Food Processing, 111 E. Delaware Place, Chicago 11, Ill. 610
Foote Bros. Gear and Machine Corp., 4545 South Western Blvd., Chicago 9, Ill. C-60
Foster Engineering Co., 835 Lehigh Ave., Union, N. J. 432
Foxboro Co., The, Foxboro, Mass. 333
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Fulton-Sylphon Div., Robertshaw-Fulton Controls Co., Knoxville 4, Tenn. 448
Furnas Electric Co., 305 Hardt Bldg., Broad St. & Columbia Ave., Philadelphia 22, Pa. 413

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Garlock Packing Co., The, Palymra, N. Y... 405
General Alloys Co., 367-405 West First St., Boston 27, Mass. 748
General American Transportation Corp., 135 S. LaSalle St., Chicago 90, Ill...42-44
General Ceramics and Steatite Corp., Keasbey, N. J. 37
General Electric Co., 1 River Road, Schenectady 5. N. Y. 708
General Laboratory Supply Co., P. O. Box 2607, Paterson, N. J. 640
General Tire & Rubber Co., The, Industrial Products Div., Wabash, Ind. S-9
Gerotor May Corp., P. O. Box 86, Baltimore 3, Md. C-155, C-156, C-157, C-158
Girdler Corp., The, Louisville 1, Ky. 18
Glascote Products, Inc., 20900 St. Clair Ave., Cleveland 17, Ohio 106
Glengarry Equipment Corp., Bay Shore, N. Y. 517
Globe Steel Tubes Co., Milwaukee, Wis. S-16, S-18
Gow-Mac Instrument Co., 100 Kings Road, Madison, N. J. C-131
Gramm Trailer Corp., 804 Fox Building, Philadelphia, Pa. S-114
Great Lakes Carbon Corp., 18 East 48th St., New York 17, N. Y. 308
Great Western Mfg. Co., Leavenworth, Kan. 741-743
Greif Bros. Cooperage Corp., The, P. O. Box 398, Lindenhurst, N. Y. 76
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Grip-Strut Div., The Globe Co., 4000 S. Princeton Ave., Chicago 9, Ill. 739
Groen Mfg. Co., 4535 W. Armitage Ave., Chicago 39, Ill. 917
Gump Co., B. F., 1325 S. Cicero Ave., Chicago 50, Ill. 23

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Hamer Oil Tool Co., 291 Gardenia Ave., Long Beach, Calif. C-127
Hanovia Chemical & Mfg. Co., 100 Chestnut St., Newark 5, N. J. C-21
Hardinge Co., Inc., York, Pa. 4
Hardinge Mfg. Co., 240 Arch St., York, Pa. 4
Haring Equipment Corp., 533 West Broadway, New York 12, N. Y. C-122
Hart-Carter Co., Minneapolis, Minn. C-41
Hart-Moisture-Meters, Grand Central Terminal, Room 1948, New York 17, N. Y. 248
Hartwell & Son, Inc., H. N., Park Square Bldg., Boston 16, Mass. 122
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Haynes Stellite Co., Div. of Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N. Y. 350
Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio . 622-624
Hercules Filter Corp., 204-208 Twenty-First Ave., Paterson 3, N. J. 78
Hercules Powder Co., Wilmington, Del.... 502
Hetherington and Berner, Inc., 701-745 Kentucky Ave., Indianapolis 7, Ind... 347
Heyl & Patterson, Inc., 55 Fort Pitt Blvd., Pittsburgh 22, Pa. S-37, S-38
High Pressure Equipment Co., P. O. Box 1174, Erie, Pa. C-135
Hoke Inc., S. Dean St. & Garrett Place, Englewood, N. J. 935
Homestead Valve Mfg. Co., Coraopolis, Pa. 444
Horix Mfg. Co., Corliss Station, Pittsburgh, Pa. C-113
Hot Oil Heater Co., Inc., The, 246 Walnut St., Newtonville 60, Mass. C-132
Hough Co., The Frank G., Libertyville, Ill. 69
Hungerford & Terry, Inc., Clayton, N. J. 642
Hydreco Div., The New York Air Brake Co., 1100 East 222nd St., Cleveland,.... ....17, Ohio 950

I

I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Philadelphia 30, Pa. 850
Illinois Testing Laboratories, Inc., 420 N. LaSalle St., Chicago 10, Ill. 205
Illinois Water Treatment Co., Rockford, Ill. 630
Imperial Brass Mfg. Co., The, 1200 W. Harrison St., Chicago 7, Ill. C-163
Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa. 836-840
Industrial and Engineering Chemistry, 1155 Sixteenth St., N. W., Washington 6, D. C. 71
Industrial Instruments Inc., 89 Commerce Road, Cedar Grove, N. J. 717
Industrial Laboratories, 201 North Wells St., Chicago 6, Ill. C-149
Industrial Models, Inc. (Del.), Arden, Wilmington, Del. C-114
Industrial Products Engineering Co., 1 Hunter St., Long Island City, N. Y. 227
Industrial Pyrometer & Supply Co., Alton, Ill. 343
Industrial Steels, Inc., 255 Bent St., Cambridge 41, Mass. 208
Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y. 918
Instruments Publishing Co., Inc., 921 Ridge Ave., Pittsburgh 12, Pa. C-121
Insul-Mastic Corporation of America, Oliver Bldg., Pittsburgh 22, Pa. C-61
International Boiler Works Co., The, E. Stroudsburg, Pa. 548
International Engineering, Inc., Dayton 1, Ohio 346
International Nickel Co., Inc., The, 67 Wall St., New York 5, N. Y. 902

J

Jabsco Pump Co., 2031 N. Lincoln St., Burbank, Calif. 326

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From Crude—to Plasma—to MSG

Carpenter Stainless Tubing

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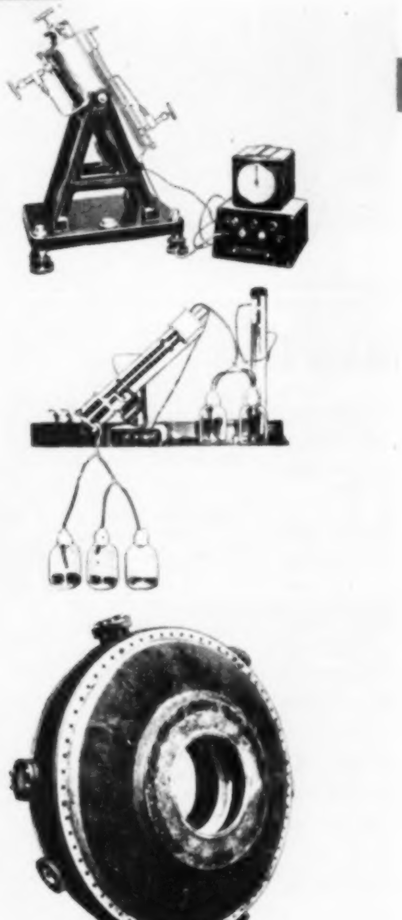

In the column at the left you see pictured a high pressure Viscosimeter used for field testing in the petroleum industry; a Blood Plasma Sterilizer that speeds processing of that vital fluid; a Calandria used to extract highly corrosive Glutamic Acid in process of making Monosodium Glutamate to add savor to food.

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In short, the manufacturers of these and many other diverse types of processing equipment know that there *is* a difference in stainless tubing—and Carpenter makes that difference. Why not get the cost-saving advantages of Carpenter's all-round service satisfaction the next time you need stainless tubing?

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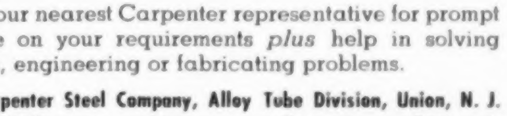

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Jarrell-Ash Co., 26 Farwell St., Newtonville, Mass. 745
Jeffrey Mfg. Co., The, Columbus 16, Ohio 201
Jenkins Bros., 100 Park Ave., New York 17, N. Y. 77
Jerguson Gage & Valve Co., 87 Fellsway, Somerville 45, Mass. 445
Johns-Manville Sales Corp., 22 East 40th St., New York 16, N. Y. 934
Johnston Pump Co., 3272 E. Foothill Blvd., Pasadena 8, Calif. S-13
Jordan Regulator Corp., 1609-10 Carew Tower, Cincinnati 2, Ohio S-77

K

Kanigen Div., General American Transportation Corp., 135 S. LaSalle St., Chicago 90, Ill. 42-44
Kathabar Div., Surface Combustion Corp., Toledo 1, Ohio 54
Kellogg Co., The M. W.
Chemical Mfg. Div., P. O. Box 469, Jersey City 3, N. J., Chemical Process Div., 225 Broadway, New York 7, N. Y. 835-839-843
Kent Co., Inc., The, Rome, N. Y. S-72
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Kimble Glass Co., P. O. Box 1035, Toledo 1, Ohio 408
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Klein Filter & Mfg. Co., 1 Hunter St., Long Island City, N. Y. 227
Knapp Mills, Inc., 23-15 Borden Ave., Long Island City 1, N. Y. 19
Knight, Maurice A., Kelley Ave., Akron 9, Ohio 7
Kontes Glass Co., Vineland, N. J. C-18
Koven & Brother Inc., L. O., 154 Ogden Ave., Jersey City 7, N. J. 834

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Laboratory Equipment Corp., Hilltop & Leco Ave., St. Joseph, Mich. S-95
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Link-Belt Co., 301 W. Pershing Road, Chicago 9, Ill. 532
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Lovejoy Flexible Coupling Co., 4949 W. Lake St., Chicago 44, Ill. S-71
Lukens Steel Co., Coatesville, Pa. 64-66
Luzerne Rubber Co., The, Trenton 7, N. J. 407
Lydon Brothers, Inc., 85 Zabriskie St., Hackensack, N. J. 735

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McGraw Hill Publishing Co., 330 West 42nd St., New York 36, N. Y............. 501

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Macbeth Corp., P. O. Box 950, Newburgh, N. Y. 833
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Magnetrol, Inc., 2110 S. Marshall Blvd., Chicago 23, Ill. 423
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Metalweld, Inc., Protective Coatings Div., Hunting Park Ave. & Fox St., Philadelphia 29, Pa. 240
Michigan Pipe Co., Bay City, Mich. S-94
Micro Metallic Corp., 30 Sea Cliff Ave., Glen Cove, N. Y. 418
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Mission Manufacturing Co., P. O. Box 4209, Houston, Tex. C-147
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Monarch Mfg. Works, Inc., 2501 E. Ontario St., Philadelphia 34, Pa. 701
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Murray Tube Works, Inc., The, P. O. Box 476, Elizabeth, N. J. S-32

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National Carbon Co., Div. of Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N. Y. 350
National Engineering Co., Simpson Mix-Muller Div., 549 W. Washington Blvd., Chicago 6, Ill. 410

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Niagara Blower Co., *405 Lexington Ave., New York 17, N. Y.* 600
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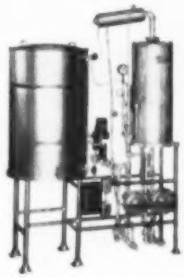

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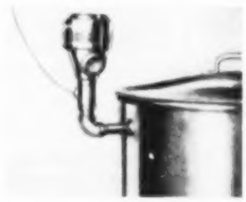

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Rietz Mfg. Co., *150 Todd Road, Santa Rosa, Calif.* ... 719-721
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Techniflex Corp., Jersey Ave., Port Jervis, N. Y. S-104
Terriss Div. of Consolidated Siphon Supply Co., 22-24 Wooster St., New York 13, N. Y. S-45

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Union Drawn Steel Div., Republic Steel Corp., *Cleveland, Ohio* 535-539
Union Iron Works, *Erie, Pa.* 324
Union Process Co., *120 Ash St., Akron 8, Ohio* C-169
U. S. Electrical Motors, Inc., *200 E. Slauson Ave., Los Angeles 54, Calif.* 740
United States Gasket Co., *Camden 1, N. J.* C-167
United States Steel Corp., *525 William Penn Place, Pittsburgh 30, Pa.;* National Tube Div., *525 William Penn Place, Pittsburgh 30, Pa.;* United States Steel Supply Div., *Foot of Bessemer St., Newark 5, N. J.;* Cyclone Fence, *Waukegan, Ill.;* Oil Well Supply Div., *2001 North Lamar St., Dallas 1, Tex.;* United States Steel Products Div., *30 Rockefeller Plaza, New York 20, N. Y.;* United States Steel Export Co., *30 Church St., New York 8, N. Y.* ... 518-522
United States Steel Export Co., *30 Church St., New York 8, N. Y.* 518-522
United States Steel Products Div., United States Steel Corp., *30 Rockefeller Plaza, New York 20, N. Y.* 518-522
United States Steel Supply Div., United States Steel Corp., *Foot of Bessemer St., Newark 5, N. J.* 518-522
United States Stoneware Co., The, *60 East 42nd St., New York 17, N. Y.* 10-12-14

Booth No.

V

Van Dorn Iron Works Co., The, Industrial Plastic Div., 2685 East 79th Street, Cleveland 4, Ohio .... S-2 & S-41

Van Nostrand Co., Inc., D., 250 Fourth Ave., New York 3, N. Y. 435

Vanton Pump Corp., Empire State Bldg., New York 1, N. Y. 715

Vapor Recovery Systems Co., The, 2820 North Alameda St., Compton, Calif... C-58

Victor Chemical Works, 141 W. Jackson Blvd., Chicago 4, Ill. 650

Vogt Machine Co., Henry, 10th & Ormsby Sts., Louisville 10, Ky. 56

W

Walker-Wallace, Inc., 137 Arthur St., Buffalo 7, N. Y. 543

Wallace & Tiernan Co., Inc., Box 178, Newark 1, N. J. 6

Walworth Co., 60 East 42nd St., New York 17, N. Y. 525

Watertown Div., The New York Air Brake Co., Watertown, N. Y. 950

Watson-Stillman Fittings Div., H. K. Porter Co., Inc., Roselle, N. J. 722

Webber Mfg. Co., Inc., 2740 Madison Ave., Indianapolis 3, Ind. S-73

Welch Mfg. Co., W. M., 1515 Sedgwick St., Chicago 10, Ill. C-42

Welding Fittings Corp., New Castle, Pa... S-88

Westinghouse Electric Corp., 511 Wood St., P. O. Box 868, Pittsburgh 30, Pa..... 200

Wheelco Instruments Div., Barber-Colman Co., 1300 Rock St., Rockford, Ill..... 744

Whitehead Metal Products Co., Inc., 303 West 10th St., New York 14, N. Y... S-25

Whiting Corp., Swenson Evaporator Company Div., Harvey, Ill. 932

Wiedeke Co., The Gustav, 1833-1901 Richard St., Dayton 1, Ohio S-12

Wiegand Co., Edwin L., 7500 Thomas Blvd., Pittsburgh 8, Pa. 810

Wiggins Gasholder Div., General American Transportation Corp., 135 S. LaSalle St., Chicago 90, Ill. 42-44

Wiggins Vapor Seals Div., General American Transportation Corp., 135 S. La-Salle St., Chicago 90, Ill. 42-44

Will Corp., Rochester 3, N. Y. 734

Will Corporation of Maryland, Baltimore, Md. 734

Williams Patent Crusher and Pulverizer Co., 2701-2723 N. Broadway, St. Louis 6, Mo. 709

Wilmington Plastics Sales Co., 810 S. Heald St., Wilmington 1, Del. S-15

Wolverine Tube Div., Calumet & Hecla, Inc., 1850 Guardian Bldg., Detroit 26, Mich. .... C-134 & C-136

Worthington Corp., Harrison, N. J. 848

Y

Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Pa. 635

York Corp., York Pa. 402

York Co., Inc., Otto H., 69 Glenwood Place, E. Orange, N. J. 646

CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 7, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Active Members will receive careful consideration if received before December 15, 1953, at the Office of the Secretary, A.I.Ch.E., 120 East 41st Street, New York 17.

Applicants for Active Membership

Angerhofer, Alvin W., *Nixon, N. J.*
Baggaley, Walter, *Beirut, Lebanon*
Benjamin, A. J., *Springfield, Mass.*
Billheimer, John S., *Pasadena, Calif.*
Cashen, John, *Freeport, Tex.*
Coughlin, Joseph F., *Wilmington, Del.*
Diesslin, Albert R., *St. Paul, Minn.*
Grekel, Howard, *Tulsa, Okla.*
Grossberg, Arnold L., *Richmond, Calif.*
Hanker, Fred C., Jr., *Altadena, Calif.*
Hawkins, John W., *Pittsburgh, Pa.*
Johnson, Joseph P., *Akron, Ohio*
Kirchgessner, Norbert H., *Kenmore, N. Y.*
Koenig, John, *Cleveland, Ohio*
Kostas, George J., *Baytown, Tex.*
Larsen, Lawrence W., *Toledo, Ohio*
Livingood, Marvin D., *Wilmington, Del.*
McCollough, G. T., Jr., *Baltimore, Md.*
Morrill, Manning C., *Cedar Rapids, Iowa*
Murray, Charles T., Jr., *Texas City, Tex.*
Nichols, Newlin S., *Dearborn, Mich.*
Reese, Francis E., *Wilbraham, Mass.*
Renquist, Melvin L., *Pasadena, Tex.*
Schraidt, John H., *Westchester, Ill.*
Tomlinson, Roy E., *Richland, Wash.*
Twiehaus, H. C., *New Martinsville, W. Va.*
Weisman, Wm. I., *Tulsa, Okla.*
Willis, A. W., *Trenton, N. J.*

Applicants for Associate Membership

Avery, Elroy C., *Port Washington, N. Y.*
Egler, Chris W., Jr., *New York, N. Y.*
Graham, Carl F., *Wyandotte, Mich.*
Palmer, Carl F., *Lake Jackson, Tex.*
Walsh, Richard A., Jr., *Texas City, Tex.*

Applicants for Junior Membership

Abrahamson, Lyle A., *Scandia, Minn.*
Acciarri, Jerry Anthony, *State College, Pa.*
Ahlemeyer, Wm. Louis, *Louisville, Ky.*
Al-Ahmad, Hamid Said, *Baghdad, Iraq*
Andrzejewski, Bernard, *Windsor, Ont.*
Athearn, Lee F., *Columbus, Ohio*
Baechle, Robert J., *Alton, Ill.*
Benzing, Robert, *Menominee, Mich.*
Berriman, Lester P., *Palo Alto, Calif.*
Bighouse, Robert L., *Columbus, Ohio*
Bond, H. Elliott, *Grand Forks, N. D.*
Born, John H., Jr., *Brooklyn, N. Y.*
Bouchillon, Dewey H., Jr., *Chattanooga, Tenn.*
Bousquet, John A., Jr., *Kingsville, Tex.*
Buwman, Russell A., *Caledonia, N. Y.*
Brozzo, J. James, *Bay City, Mich.*
Busche, Robert M., *Charleston, W. Va.*
Cosgrove, Donald V., *Bay City, Mich.*
Curry, Duncan, III, *Los Alamos, N. M.*
D'Amico, Frank J., *New Haven, Conn.*
Daniels, David J., *Columbus, Ohio*
Danzberger, Alexander H., *Cambridge, Mass.*
Dempsey, James F., *Marcus Hook, Pa.*
Elgert, Oscar J., *San Jose, Calif.*
Emanuel, Abraham G., *Aberdeen Proving Ground, Md.*
Griffith, E. H., Jr., *E. Elmhurst, N. Y.*

CANDIDATES

Haas, Ralph Lewis, Cincinnati, Ohio
Hansford, David L., Oak Ridge, Tenn.
Harrison, Robert S., Inglewood, Calif.
Harvey, Sidney R., Gloucester, Mass.
Hedge, Thomas E., Mentor, Ohio
Heisler, William B., St. Louis, Mo.
Hottle, Boyd E., Concord, Calif.
Janosik, James P., Richmond, Va.
Jenkins, Jerry G., Baytown, Tex.
Kassan, Jordan D., New York, N. Y.
Kosloff, William A., New York, N. Y.
Kowalsky, Mel, Brooklyn, N. Y.
Kroger, Raymond P., N. Augusta, S. C.
Levitz, Norman M., Lemont, Ill.
Liesegang, Walter Paul, Rutherford, N. J.
Lloyd, Charles S., Baytown, Tex.
Loeding, John W., Brookfield, Ill.
Long, E. W., Jr., Texas City, Tex.
Maag, William L., Canton, Ohio
Mardis, Wayne F., Birmingham, Ala.
Martin, Carl J., New Orleans, La.
McCall, James A., Springfield, Mass.
McPherson, William J., Chicago, Ill.
Mears, Judson J., Jr., Pittsburgh, Pa.
Meek, Paul D., Baytown, Tex.
Mino, George M., Buffalo, N. Y.
Nix, Harold C., Baytown, Tex.
Oosterom, Eugene C., Bellmore, N. Y.
Oshta, Tom, Chicago, Ill.
Potter, Willard H., Dayton, Ohio
Reneau, Verlyn L., Wichita, Kan.
Royder, Thomas H., Baytown, Tex.
Russell, Richard R., Portsmouth, Ohio
Scheffer, Louis K., Jr., Rochester, N. Y.
Schmitt, William J., New Haven, Conn.
Shumaker, Richard H., Parlin, N. J.
Smolin, Michael, New York, N. Y.
Starkey, Bart. J., Wilmington, Del.
Stelzer, Harold L., Jr., Ontario, N. Y.
Suber, Michael J., Schenectady, N. Y.
Sugalski, Alfred A., Schenectady, N. Y.
Todd, James B., Jr., Baton Rouge, La.
Topper, Leonard, Baltimore, Md.
Walters, Wally Z., Appleton, Wis.
Weger, Eric, Baltimore, Md.
Wheeler, Rosetta R., McLean, Va.
Wiedekamp, Karl E., Spokane, Wash.
Williamson, Frank P., Ponca City, Okla.
Wynne, Alfred M., Orono, Me.

FUTURE MEETINGS AND SYMPOSIA OF A.I.Ch.E.

Chairman of the A.I.Ch.E. Program Committee

Loren P. Scoville, Jefferson Chemical Company, Inc. 260 Madison Ave., New York 16, N. Y.

MEETINGS

Annual—St. Louis, Mo., Hotel Jefferson, Dec. 13-16, 1953.
TECHNICAL PROGRAM CHAIRMAN: G. T. Skaperdas, Assoc. Dir., Chem. Eng. Dept., M. W. Kellogg Co., 225 Broadway, N. Y. 7, N. Y.
ASST. CHAIRMAN: N. Morash, Titanium Div., National Lead Co., P. O. Box 58, South Amboy, N. J.

Washington, D. C., Statler Hotel, March 7-10, 1954.
TECHNICAL PROGRAM CHAIRMAN: George Armistead, Jr., Consult. Chem. Eng., George Armistead & Co., 1200 18th St. N.W., Washington 6, D. C.

Springfield, Mass., Hotel Kimball, May 16-19, 1954.
TECHNICAL PROGRAM CHAIRMAN: E. B. Fitch, Asst. to Res. Dir., The Dorr Co., Westport, Conn.

Ann Arbor, Mich., Univ. of Mich., Ann Arbor, Mich., June 20-25, 1954—Conference on Nuclear Engineering.
TECHNICAL PROGRAM CHAIRMAN: D. L. Katz, Chairman, Dept. of Chem. and Met. Eng., Univ. of Mich., 2028 E. Eng. Bldg., Ann Arbor, Mich.

Glenwood Springs, Colo., Hotel Colorado, Sept. 12-15, 1954.
TECHNICAL PROGRAM CHAIRMAN: Dr. Charles H. Prien, Head, Chem. Div., Denver Res. Inst., Univ. of Denver, Denver 10, Colo.

Annual—New York, N. Y., Statler Hotel, Dec. 12-15, 1954.

Louisville, Ky., Kentucky Hotel, March 20-23, 1955.
TECHNICAL PROGRAM CHAIRMAN: R. M. Reed, Tech. Dir., Gas Proc. Div., The Girdler Corp., Louisville 1, Ky.

Houston, Texas, Shamrock Hotel, May 1-4, 1955.
TECHNICAL PROGRAM CHAIRMAN: J. L. Franklin, Res. Assoc., Humble Oil & Refining Co., P. O. Box 1111, Baytown, Texas.

Lake Placid, N. Y., Lake Placid Club, Sept. 25-28, 1955.
TECHNICAL PROGRAM CHAIRMAN: L. J. Coulthurst, Chief Proc. Designer, Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.

Annual—Detroit, Mich.—Statler Hotel, Nov. 27-30, 1955.
TECHNICAL PROGRAM CHAIRMAN: T. J. Carron, Head, Chemical Tech. Office, Ethyl Corp., Res. Labs., 1600 West Eight Mile Road, Detroit 20, Mich.

SYMPOSIA

SYMPOSIA FOR WASHINGTON MEETING

Mixing

Patents

Chemical Engineering in the Fertilizer Industry

Liquid Entrainment and Its Control

Chemical Engineering Fundamentals

New Metal Technology

Use of Computers in Chemical Engineering

Polymeric Materials of Construction
CHAIRMAN: C. C. Winding, Assist. Dir., College of Eng., Cornell Univ., Ithaca, New York.
MEETING—Springfield, Mass.

Nuclear Engineering
CHAIRMAN: D. L. Katz, Chairman (Address: See Ann Arbor Meeting).
MEETING—Ann Arbor, Mich.

Agglomeration
CHAIRMAN: A. P. Weber, International Engineering, Inc., 15 Park Row, New York, N. Y.
MEETING—Glenwood Springs, Colo.

Reaction Kinetics
CHAIRMAN: N. R. Amundson, Dept. of Chem. Eng., Univ. of Minnesota, Minneapolis 14, Minn.
MEETING—New York, N. Y.

Gas Absorption
CHAIRMAN: R. L. Pigford, Div. of Chem. Eng., Univ. of Delaware, Newark, Del.
MEETING—New York, N. Y.

Solvent Extraction
CHAIRMAN: Dr. R. B. Beckmann, Dept. Chem. Eng., Carnegie Inst. of Tech., Schenley Park, Pittsburgh 13, Pa.
MEETING—New York, N. Y.

Heat Transfer
CHAIRMAN: R. L. Pigford, Div. of Chem. Eng., Univ. of Delaware, Newark, Del.
MEETING—Louisville, Ky.

Centrifugation
CHAIRMAN: J. O. Maloney, Chairman, Dept. Chem. Eng., Univ. of Kansas, Lawrence, Kan.

Nucleation Processes
CHAIRMAN: E. L. Piret, Dept. Chem. Eng., Univ. of Minn., Minneapolis 14, Minn.

Submitting Papers

Members and nonmembers of the A.I.Ch.E. who wish to present papers at scheduled meetings of the Institute should follow the following procedure.

First, write to the Secretary of the A.I.Ch.E., Mr. S. L. Tyler, American Institute of Chemical Engineers, 120 East 41st Street, New York, requesting three copies of the form "Proposal to Present a Paper Before the American Institute of Chemical Engineers." Complete these forms and send one copy to the Technical Program Chairman of the meeting for which the paper is intended, one copy to the Chairman of the A.I. Ch.E., Program Committee, address at the top of this page, and one copy to the Editor of Chemical Engineering Progress, Mr. F. J. Van Antwerpen, 120 East 41st Street, New York.

If you wish to present the paper at a particular symposium, one copy of the form should go to the Chairman of the symposium instead of the Technical Program Chairman of the meeting.

Before Writing the Paper

Before beginning to write your paper you should obtain from the meeting Chairman, or from the office of the Secretary of the A.I.Ch.E., at 120 East 41st St., New York, a copy of the A.I.Ch.E. Guide to Authors, and Guide to Speakers. These cover the essentials required for submission of papers to the A.I. Ch.E. or its magazines.

Copies of Manuscript

Five copies of each manuscript must be prepared. For meetings, one should be sent to the Chairman of the symposium, and one to the Technical Program Chairman of the meeting at which the symposium is scheduled. If no symposium is involved, the two copies should be sent to the Technical Program Chairman. The other copies should be sent to the Editor's office since manuscripts are automatically considered for publication in Chemical Engineering Progress, or the symposium series of Chemical Engineering Progress, but presentation at a meeting is no guarantee that they will be accepted.

DEADLINE DATES FOR PAPERS

SPRINGFIELD MEETING—January 9, 1954
ANN ARBOR MEETING—February 15, 1954
GLENWOOD SPRINGS MEETING—May 12, 1954
NEW YORK MEETING—August 12, 1954
LOUISVILLE MEETING—November 20, 1954
HOUSTON MEETING—definite dates have not been set.
LAKE PLACID MEETING—May 25, 1955
DETROIT MEETING—July 27, 1955

Secretary's Report

The Executive Committee transacted the necessary business for the month of October by mail ballot. The Minutes of the Executive Committee for the previous month as well as the Treasurer's Report for the month of August were approved as issued. The candidates for membership whose names were published in the September issue of Chemical Engineering Progress were declared elected.

On recommendation of the Student Chapters Committee the following were appointed as Student Chapter Counselors:

University of California—C. W. Tobias to succeed K. F. Gordon.
Louisiana Polytechnic Institute—Virgil Orr.
New York University—M. Newman to succeed C. J. Marsel.
University of Virginia—James H. Gary to succeed J. W. Eldridge.

Secretary reported the addition of George L. Dienes to the Suspense List because of his entrance into the Armed Forces and the removal of Brenton S. Halsey, Marshall Dick, Ralph A. Morgen, Jr., and T. E. Peak from the Suspense List because they had now resumed civilian status.

The following personnel appointments were made to the Membership Committee on the recommendation of John Lee Olsen, chairman:

T. Hooker, (Western N. Y.) to succeed J. J. Zullo.
W. P. Cadogan (Ohio Valley) to succeed S. Englund.
J. C. Linak (Charleston) to succeed A. H. Crowley.
J. J. Levitsky (New Haven Chem. Eng. Club).
A. C. Burr (North Dakota Chem. Eng. Club).
R. H. Gray, Jr. (Midland) to succeed E. G. Sprague.
E. Garelis (Detroit) to replace A. J. Miller.
H. Harris (Texas Panhandle) to succeed W. B. Polk.
H. D. Carlson (Philadelphia-Wilmington) to succeed A. N. Pedersen.

On the suggestion of G. F. Jenkins, chairman, the following men were appointed to the Public Relations Committee:

W. A. Resch to succeed H. A. Scott.
S. G. Bankoff (Knoxville-Oak Ridge) to succeed W. B. Harrison.
J. F. Pollock (Tulsa).

(Continued on page 98)

SECRETARY'S REPORT

(Continued from page 97)

Four elections to membership were rescinded because of nonacceptance on the part of the candidates for membership.

Secretary reported that W. A. Cunningham had been appointed Institute representative to attend the inauguration of Dr. Logan Wilson as president of University of Texas on Oct. 29, and that G. G. Brown had been appointed Institute representative to attend the inauguration of C. B. Hilberry as president of Wayne University on Nov. 9.

At the suggestion of President Nichols and on the basis of mail vote by the entire Council, C. B. Roen was appointed chairman of the Vocational Guidance Committee for 1954.

W. L. McCabe was appointed to succeed C. G. Kirkbride as Institute representative on the Engineers' Council for Professional Development for a three-year term, beginning October, 1953.

ST. LOUIS STORY

(Continued from page 26)

for pizza pie and other Italian food; the Park Plaza Hotel Gourmet Room; Petit Pigalle for Parisian atmosphere; Ruggeri's for charcoal broiled steaks; the Sea Isle for Cantonese and Chinese-American fare; the Shangri-La, and S. S. Tahiti with the type of food that its name implies.

After a good meal, a visitor with time between technical talks and plant trips should not fail to see the second largest botanical garden in the world—the Shaw Garden, the animal exhibits at the zoo, the City Art Museum, and the million-dollar all steel S.S. "Admiral," largest river excursion steamer in the United States.

And when you attend the meeting here Dec. 13-16, 1953—whether you pause on the levee to watch the great Mississippi sliding quietly to the sea—whether you ponder the prehistoric Mound Builders who once trod this ground and piled it into monstrous cairns—whether you see in your mind's eye St. Louis pioneers, or Robert E. Lee channeling the river, or Huckleberry Finn lazily floating by—whether you note the contrasts here, like modern TV antenna arrays jutting from nineteenth century mansard roofs—whether you mingle with downtown throngs of solid Americans—whether you admire the engineering "know-how" evident in busy plants turning out goods for us all—you may be inclined to agree that St. Louis is a city with a colorful past and a bright future.

The End

TECHNICAL PROGRAM

(Continued from page 19)

AND WIRES, J. T. Banchero, G. E. Barker, and R. H. Boll, University of Michigan, Ann Arbor, Mich.

10:10 A.M.—TWO-PHASE HEAT TRANSFER IN NATURAL CIRCULATION EVAPORATOR, Edgar L. Piret and H. S. Isbin, University of Minnesota, Minneapolis, Minn.

10:40 A.M.—THE GENERATION OF STEAM FROM LIQUID METAL AT HIGH HEAT FLUXES, E. C. King and R. C. Andrews, Mine Safety Appliances Co., Callery, Pa.

11:00 A.M.—BOILING HEAT TRANSFER WITH LIQUID METAL, Robert E. Lyon, Alan S. Foust, and Donald L. Katz, University of Michigan, Ann Arbor, Mich.

11:20 A.M.—REMARKS ON THERMAL ENTRANCE REGION HEAT TRANSFER IN LIQUID-METAL SYSTEMS, H. P. Poppendiek and W. B. Harrison, Oak Ridge National Laboratory, Oak Ridge, Tenn.

11:40 A.M.—A CRITICAL ANALYSIS OF METAL WETTING AND GAS ENTRAINMENT IN HEAT TRANSFER TO MOLTEN METALS, W. C. MacDonald and R. C. Quittenton, University of Toronto, Ont.

TECHNICAL SESSION NO. 11

Dust and Mist Collection

9:00 A.M.—ELEMENTS OF DUST AND MIST COLLECTION, C. E. Lapple, Ohio State University, Columbus, Ohio.

9:30 A.M.—THE HERSEY REVERSE-JET FILTER, K. J. Caplan, St. Louis, Mo.

10:00 A.M.—FILTRATION OF RADIOACTIVE AEROSOLS BY GLASS FIBERS, A. G. Blasewitz and B. F. Judson, General Electric Co., Richland, Wash.

10:30 A.M.—PERFORMANCE OF WET DUST SCRUBBERS, C. E. Lapple and H. J. Kamack, Du Pont Co., Inc., Wilmington, Del.

11:00 A.M.—PERFORMANCE CHARACTERISTICS OF CENTRIFUGAL SCRUBBERS, G. A. Johnson, S. K. Friedlander, M. W. First, and L. Silverman, Harvard School of Public Health, Boston, Mass.

TECHNICAL SESSION NO. 12

Fundamentals of Digital Computers

9:00 A.M.—John R. Bowman, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

9:15 A.M.—FUNCTIONS OF DIGITAL COMPUTERS, H. H. Aiken, Harvard Computation Laboratory, Harvard University, Cambridge, Mass.

10:00 A.M.—FUNCTIONS OF COMPUTER COMPONENTS, J. A. Rajchman, R. C. A. Laboratories, Princeton, N. J.

10:45 A.M.—PREPARATION OF PROBLEMS FOR DIGITAL COMPUTERS, A. S. Householder, Oak Ridge National Laboratories, Oak Ridge, Tenn.

TECHNICAL SESSION NO. 13

Heat Transfer

2:00 P.M.—HEAT TRANSFER IN FLUIDIZED BEDS, EFFECTIVENESS OF GAS-SOLID CONTACT, W. W. Wamsley and L. N. Johanson, University of Washington, Seattle, Wash.

2:20 P.M.—HEAT TRANSFER COEFFICIENTS FOR GASES, EFFECT OF TEMPERATURE LEVEL AND RADIATION, H. J. Ramey, J. B. Henderson, and J. M. Smith, Purdue University, Lafayette, Ind.

2:40 P.M.—CONVECTIVE HEAT TRANSFER FROM A GAS STREAM AT HIGH TEMPERATURE TO A CIRCULAR CYLINDER NORMAL TO THE

FLOW, S. W. Churchill and J. C. Brier, University of Michigan, Ann Arbor, Mich.

3:00 P.M.—THE MELTING OF SOLIDS, T. K. Ross, University of Birmingham, Birmingham, England.

3:20 P.M.—HEAT TRANSFER PROPERTIES OF LIQUID-SOLID SUSPENSIONS, Clyde Orr, Jr. and J. M. Dallavalle, The Georgia Institute of Technology, Atlanta, Ga.

3:40 P.M.—HEAT TRANSFER BETWEEN IMMISCIBLE LIQUIDS, S. S. Grover and J. G. Knudsen, Oregon State College, Corvallis, Ore.

4:00 P.M.—NON-ISOTHERMAL FLOW AND HEAT TRANSFER INSIDE VERTICAL TUBES, R. L. Pigford, University of Delaware, Newark, Del.

4:20 P.M.—HEAT TRANSFER TO VISCOUS MATERIALS IN JACKETED AGITATED KETTLES, V. W. Uhl, Lehigh University, Bethlehem, Pa.

TECHNICAL SESSION NO. 14

Dust and Mist Collection

2:00 P.M.—PARTICLE SIZE DISTRIBUTION IN HYDROSCOPIC AEROSOLS, G. R. Gillespie and H. F. Johnstone, University of Illinois, Urbana, Ill.

2:30 P.M.—AN ANALYZER FOR MEASURING THE ELECTRIFICATION OF DUSTS, MISTS, AND SMOKES, C. Orr, Jr., B. L. Hinkle, and J. M. Dallavalle, Georgia Institute of Technology, Atlanta, Ga.

TECHNICAL SESSION NO. 15

Drying

2:00 P.M.—ANALYSIS OF ROTARY DRIER AND COOLER PERFORMANCE, W. C. Saeman, Ecusta Paper Corp., Pisgah Forest, and T. R. Mitchell, Jr., Olin Industries, Inc., New Haven, Conn.

2:30 P.M.—THE PERFORMANCE OF A CROSS-FLOW ROTARY DRIER, J. D. Seader and W. R. Marshall, Jr., University of Wisconsin, Madison, Wis.

3:00 P.M.—SIMULTANEOUS HEAT—AND MASS—TRANSFER IN A NON-ISOTHERMAL SYSTEM: THROUGH-FLOW DRYING IN THE LOW-MOISTURE RANGE, W. B. Van Arsdel, associate director, Western Regional Research Laboratory, Albany, Calif.

3:30 P.M.—SPRAY DRYING OF SOAP, Lawrence E. Stout, Jr., research and development dept., Colgate-Palmolive-Peet Co., Jersey City, N. J.

4:00 P.M.—THE DIELECTRIC DRYING OF GELATINOUS AND FIBROUS MATERIALS, E. D. Besser, U. S. Naval Ordnance Test Station, China Lake, Calif., and Edgar L. Piret, professor of chemical engineering, University of Minnesota, Minneapolis, Minn.

4:30 P.M.—THE PERFORMANCE OF VANED DISK ATOMIZERS, W. M. Herring, Jr., and W. R. Marshall, Jr., University of Wisconsin, Madison, Wis.

LOCAL SECTION NEWS

From Atlanta we learn from H. H. Sineath that forty-eight members and guests met recently on the Georgia Tech campus to hear Ivy M. Parker, Plantation Pipe Line Co., discuss the engineering aspects of petroleum pipe-line operations.

Following the meeting at Georgia Tech, the group reassembled at the Doraville station of the Plantation Pipe Line Co. for an interesting guided tour.

The fortieth general meeting of the East Tennessee Section was held Sept. 28, 1953, in the auditorium of Tennessee Eastman Co. Fifteen members and three guests were present. R. O. Hubbard, chairman of the program committee, announced that the local section was sponsoring a series of talks on distillation to be held in November. The plans include three separate meetings at which talks will be presented by local technical people. Those people who are scheduled to take part in this presentation are G. A. Akin, C. C. Hyatt, Bob Williams, Warren Grubb, Carl Wilson, and Tom Elder. Dr. Harry Coover, senior research chemist, research laboratories, Tennessee Eastman Co., and guest speaker of the evening, presented a talk on soil-conditioning agents. The talk was well received, according to the reporter Toy F. Reid.

B. H. Rosen writes us that more than 350 attendees were present at the New York Section triple symposium on "Management," "New Materials of Construction," and "Solids Handling" which was held at the New Yorker Hotel Oct. 22. Topics discussed at the "Management" sessions varied from effective utilization of personnel to methods of financing chemical growth. New developments in plastics and metals, and a survey of solids handling, as well as examples of solids-handling problems, were covered by the other symposia. There was representation from all points on the Eastern seaboard at the meeting, from the Ichthyologists of Boston to the members of the Delaware and Washington sections, with a goodly contingent from Philadelphia.

New officers of the New York section reported by A. Jonnard are as follows:

Chairman............F. B. White
Vice-Chairman.Richard F. Shaffer
Secretary...Wesley T. Dorsheimer
Treasurer........Stanley B. Adler

An organizational meeting of the New Haven Chemical Engineers Club was held on Sept. 29 at the Yale University Sterling Chemistry Laboratory. The meeting was attended by sixty members of the chemical engineering profession from New Haven and the surrounding area.

A proposed set of bylaws for the new organization was presented, reviewed, amended, and approved for adoption at the next meeting.

The November meeting will be held Nov. 24 and will be devoted to a discussion of "Materials Handling in the Chemical Industry" by A. Strong of the American Cyanamid Co. Yale University Sterling Chemistry Laboratory, says J. J. Levitzky, is the appointed place for this meeting.

H. E. Gross has sent in the names of the officers who will serve the Chicago Section for the 1953-54 fiscal year. They are as follows:

Chairman—J. Robert B. Blizzard, Transparent Package Co.

Vice-Chairman—R. H. Rogge, Corn Products Refining Co.

Secretary—H. F. Nolting, Standard Oil Co.

Treasurer—E. H. Vause, Standard Oil Co.

The Baton Rouge Section, W. A. Phillips reports, met at the Heidelburg Hotel, Sept. 17, for the first meeting following the summer recess. Dr. Louis Koenig, associate director of the Southwestern Research Institute, gave a talk titled "The Technical Aspects of Air Pollutions," which was well received by a group of approximately eighty members and guests.

At the October meeting the Section heard Leon Godchaux, vice-president of Godchaux Sugars, New Orleans, speak on the management of a varied production enterprise.

The first dinner meeting of the 1953-54 season of the Pittsburgh Section was held at the Sheraton Hotel, Oct. 7. Messrs. Morrissey and Black report an attendance of approximately sixty-five section members and friends.

The meeting honored the three past A.I.Ch.E. National Presidents from the Pittsburgh Section: E. R. Weidlein (1927-28) president, Mellon Institute of Industrial Research; W. N. Jones (1939-40) vice-president, Carnegie Institute of Technology and F. C. Frary (1941), formerly director of research, Aluminum Co. of America. Dr. Frary was unable to attend. Life-time memberships were presented to these three men following a short address by Drs. Weidlein and Jones.

The main speaker of the evening was W. T. Nichols, President of A.I.Ch.E. and director, general engineering department, Monsanto Chemical Co., who spoke about "Institute Problems and Programs."

In closing, Mr. Nichols proposed to the Section that the participation of the younger members of the Institute be fostered. He also encouraged members to show an interest in the student chapters in the district by offering to discuss one's specialty to chemical engineering classes.

(*More Local Section on page 102*)

Nelson W. Taylor, manager, Fluorochemicals Department, Minnesota Mining and Manufacturing Co., gave an illustrated address on Fluorochemicals before the Chemical Engineers Club of Washington on Oct. 5 at the Burlington Hotel.

Howard R. Batchelder, associate consulting chemist at Battelle Memorial Institute, discussed the Bureau of Mines Synthetic Fuels Demonstration Plant at Louisiana, Mo., at a dinner meeting of the Central Ohio Section, Oct. 21. The meeting, held at Ohio State University Faculty Club, started at 6:30. C. J. Geankoplis, professor of chemical engineering at the Ohio State University, presided.

F. Morgan Warzel reports that the state-wide meeting held in Bartlesville, Oct. 10, attracted approximately 125 visitors. Titles of the papers presented in the Petro-Chemical and the Personal Improvement symposia are as follows:

PETRO-CHEMICAL SYMPOSIUM

Presiding: H. L. Hays

9:20 A.M.—CHEMOFINING, PETROLEUM'S FUTURE? by J. H. Eppard and M. R. Wingard, Blaw-Knox Co.

9:50 A.M.—APPLICATION OF INFRARED ANALYZERS TO CONTINUOUSLY MONITOR AND CONTROL PLANT STREAMS by D. E. Berger, Phillips Petroleum Co.

10:45 A.M.—START-UP OF TUSCOLA HYDROCARBON RECOVERY UNITS by J. F. McDonald, National Petro-Chemicals Corp.

11:15 A.M.—THE CHEMICO UREA PROCESS by L. H. Cook, Chemical Construction Corp.

PERSONAL IMPROVEMENT SYMPOSIUM

Presiding: Evert W. Kilgren

2:00 P.M.—TECHNICAL IMPROVEMENT by N. K. Anderson, Deep Rock Oil Corp.

2:30 P.M.—SUPERVISOR TRAINING by Warren L. Felton, Phillips Petroleum Co.

3:30 P.M.—RELATIONSHIP OF AN ENGINEER TO HIS SUBORDINATES AND HIS SUPERVISORS by I. Arthur Anson, Bell Oil and Gas Co.

4:00 P.M.—REALIZATION OF HUMAN ASPIRATIONS—A FUNCTION OF MANAGING by H. G. Thuesen, Oklahoma A. & M. College.

A glance at the activities of the Central Pennsylvania Chemical Engineer's Club, Danville, Pa., reveals an interesting prospectus. W. E. Keppler, chairman of the Club, sent in the following report:

Arthur L. Smith of R.C.A. talked at the October meeting on "Luminescent Materials and Their Applications," and B. M. Reynolds, vice-president of Merck & Co., Inc., addressed the Club in November on "Opportunities for Men with Engineering Training in Fields Other Than Pure Engineering."

The Club is sponsoring a series of classes to cover the solution of problems given in the Pennsylvania Professional Engineer's Examinations. The instructor is W. E. Keppler; co-instructors are J. Lago and C. Stahl. The class has an enrollment of twenty. The Club is also planning to set up a Professional Guidance Committee to visit the high schools in the area and discuss with the students the profession of chemical engineering.

Mr. Keppler also informs us that R. Ghelardi has replaced L. Berkowitz on the Executive Committee. He left the area to accept a position in the city of Buffalo, and J. Plonko has been appointed secretary.

The first seasonal meeting of the Boston Section, Ichthyologists, was held on Oct. 9. R. W. Wilson, sales promotion manager, lamp division, General Electric, presented an interesting talk entitled "Light Sorcery." Mr. Wilson's exhibit and lecture were largely based on information from G.E.'s Lighting Laboratory at Nela Park. A. G. Smith, secretary, sent in news of the meeting.

Carl M. Kron informs us that the Texas Panhandle Local Section has resumed regular meetings after its summer recess. At the Sept. 22 meeting which was held in the Hughes Bldg. in Pampa, Tex., B. B. Morton of the International Nickel Co. presented a film entitled "Corrosion in Action." The attendance at the meeting was eighty members and guests, representing eight companies, namely, Cabot Carbon Co., Celanese Corp., Cities Service Oil Co., Continental Carbon Co., Dearborn Chemical Co., J. M. Huber Corp., Phillips Chemical Co., and Phillips Petroleum Co.

—H.R.G.

PEOPLE

L. C. Kemp, Jr., formerly director of research, has been made assistant to the vice-president of the refining department of The Texas Co. Upon graduation from Rice Institute in 1929, he entered the service of The Texas Co. at its Port Arthur research laboratory. After holding several administrative positions in the Port Arthur, Tex., and Beacon, N. Y., laboratories, Mr. Kemp was made director of research of the company in 1941.

Mr. Kemp has served the A.I.Ch.E. as chairman of the Committee on Admissions (1952-53) after several years as member, and two years as vice-chairman. He is the adviser to the Membership Committee, representative to E.C.P.D. on the Committee on Professional Recognition, and representative to the U. S. National Committee of the World Power Conference.

Llewellyn S. Howe has joined the commercial development division of Mathieson Chemical Corp., New York, as assistant to the vice-president in charge of basic materials and facilities. He was formerly manager of the company's hydrocarbon chemicals plant at Doe Run, Ky. Mr. Howe joined the company in 1951 as a process development engineer.

Peter A. Puleo, who established his own business, the Industrial Process Equipment Co., the beginning of this year, will represent Black, Sivalls & Bryson, Inc., in the St. Louis district in its line of safety heads and vent valve equipment. He has had experience as sales engineer with both the Crane Co. and the Fischer and Porter Co. Mr. Puleo spent two years in the St. Louis University School of Business and graduated with a B.S. degree from the School of Chemical Engineering, Washington University.

Thomas B. Kimball has recently been appointed general manager of refineries, Sinclair Refining Co. He joined the Sinclair organization in 1930 in the research and development department at East Chicago, Ind. Before being transferred to the New York office in 1943, he was in charge of the cracking division and of the process engineering and development of light-oil processes at the East Chicago refinery. In 1950 he was appointed assistant manager of refineries, the position he held prior to his present appointment. During World War II he was active in the production of aviation gasoline, particularly by catalytic cracking and served on several wartime committees.

Cecil W. Humphreys, formerly general manager and manager of development in the manufacturing department, Shell Chemical Corp., New York, is now vice-president in charge of manufacturing. He joined the company as a laboratory assistant at the Pittsburg, Calif., plant, later working as chief chemist at the Martinez, Calif., plant, and as assistant superintendent of the Dominguez plant. He moved to Houston, Tex., in 1941, to act as manager of the chemical plant through the war years. In 1946 he became manager of nation-wide operations in Shell Chemical's manufacturing department. Dr. Humphreys received his Ph.D. in chemistry and engineering from Stanford University.

Joseph P. Berndt, Jr., in the general engineering department of Monsanto Chemical Co., St. Louis, Mo., since 1951, has been transferred to the phosphate division, development department. Mr. Berndt received his B.S. degree in chemical engineering from the Missouri School of Mines in 1943. After service with the Army Corps of Engineers during World War II, he was employed for five years by the engineering department of Carbide & Carbon Chemicals Corp., South Charleston, W. Va.

Gustav Egloff, director of research for Universal Oil Products Co. is now in Japan taking part in the 75th anniversary celebration of the Chemical Society of Japan. Dr. Egloff, the only American to address the society, will talk on "The Platforming Process," "Chemicals from Petroleum," and "Catalytic Reactions in Oil Refining."

Robert V. Jelinek has accepted the position of assistant professor of chemical engineering at Columbia University. He was formerly with Standard Oil Development Co.

Charles Eisenmann has been appointed representative of the state of Virginia for the Falls Industries, Inc., Solon, Ohio, and the General Ceramics & Steatite Corp., Keasbey, N. J., with office at the latter corporation.

Nathan Gilbert, formerly chemical engineer with the Tennessee Valley Authority, Wilson Dam, Ala., has recently joined the University of Cincinnati College of Engineering staff as associate professor of chemical engineering. He received his B.Sc. degree in chemistry from the University of California and a Ph.D. in physical chemistry from the University of Wisconsin.

WRENSHALL AND SHARRARD IN NEW JOBS AT PFIZER

C. L. Wrenshall has been appointed associate director of the technical service department of Chas. Pfizer & Co., Inc. and **George F. Sharrard** succeeds Dr. Wrenshall as administrative assistant to director of sales development.

Dr. Wrenshall, who joined Pfizer in 1952, is a graduate of the University of Saskatchewan and McGill University. Prior to joining Pfizer he served as assistant technical superintendent of Du Pont's Chickasaw Ordnance Works, as head of the division of organic and agricultural chemistry at Southern Research Institute, and as technical director for Foremost Dairies, Inc.

Before joining Pfizer, Mr. Sharrard was with Westvaco Chemical Division of Food Machinery and Chemical Corp., where he was manager of the technical service division. Previously he had been affiliated with Eastman Kodak.

Charles G. Schmitz, formerly assistant superintendent and chief chemist of the Mobile, Ala., refinery, is now technical assistant to the manager of production Eastern at the Eastern division office of The American Bitumuls & Asphalt Co., Baltimore, Md., subsidiary of The Standard Oil Company of California.

Kenneth Irey has been appointed chemical production manager for Heyden Chemical Corp. He joined the company as production manager at the Garfield plant in 1949, becoming assistant manager of that plant in 1952. Prior to his going to Heyden he was plant superintendent in the plastics plant, Monsanto Chemical Co., Springfield, Mass., plant superintendent at Resinox Corp., and with Commercial Solvents Corp. as research chemist. Mr. Irey received his M.S. degree in chemical engineering from Carnegie Tech.

Robert A. Byorum, with Spencer Chemical Co. Pittsburg, Kans., since 1948, serving as an engineer, project engineer, and as supervising project manager in the engineering department, has become assistant chief engineer. A graduate of the University of Oklahoma with a B.S. degree in chemical engineering, Mr. Byorum worked for the Du Pont Co., Pryor, Okla., Magnolia Petroleum, Dallas, Tex., and Ford, Bacon and Davis construction Corp., Monroe, La., prior to his employment with Spencer.

William F. Waldeck has become director of research and development of Wyandotte Chemicals Corp., Wyandotte, Mich. A chemical engineering graduate and recipient of a doctorate in chemistry from New York University, Dr. Waldeck went to Wyandotte in 1939 and served as assistant director of technical service, assistant director of research, and director of chemical research. He had previously been associated with the Columbia Chemical Division of Pittsburgh Plate Glass Co., where he was acting director of research.

Thomas H. Cox is now assistant technical superintendent at the Victoria plant, Du Pont Co., Victoria, Tex., engaged in development work on the process for making adiponitrile, an intermediate in the manufacture of nylon. He joined the company in 1948 as a chemical engineer at the Sabine River Works, Orange, Tex.

C. M. Hickey, formerly general superintendent of plants in the Southern division, Consolidated Chemical Industries, Inc., Houston, Tex., is now manager of manufacturing. A chemical engineering graduate of Rice Institute, Mr. Hickey has been with the company since 1924.

STAFF CHANGES AT PURDUE UNIVERSITY

William H. Tucker has joined the staff of Purdue as an associate professor of chemical engineering. Dr. Tucker was formerly employed by Servel, Inc. in Evansville, Ind., as supervisor of research.

Thomas C. Doody, associate professor of chemical engineering, has left the campus to spend two years at the Taiwan College of Engineering as part of Purdue's program to assist in the development of engineering education on the island of Formosa.

J. M. Smith of the chemical engineering department has been awarded a Guggenheim Fellowship and a Fulbright Grant to spend the academic year in Holland. He is working on research projects at the Laboratorium voor Chemische Technologie at Delft.

Carroll O. Bennett, assistant professor of chemical engineering, has returned to Purdue after a year's stay at the University of Nancy, France. While at Nancy he assisted in the establishment of a chemical engineering curriculum and laboratory.

John P. Coe, vice-president of the United States Rubber Co., has been appointed to handle the company's interests in the transfer of synthetic rubber plants from the government. He has been detached from his duties as general manager of the company's Naugatuck chemical division to devote full time to his new assignment. His major duty will be to work with the synthetic rubber plant disposal commission to be appointed by President Eisenhower. As head of the chemical division, Mr. Coe supervised the design and construction of two of the fifteen government GR-S synthetic rubber plants and managed the operation of five of them.

Charles A. Campbell, formerly group leader of lubricating oil group, development department, Tide Water Associated Oil Co., Bayonne, N. J., is now in Japan acting as technical adviser to Mitsubishi Oil Co., Ltd., an affiliate of Tide Water Associated.

Ralph N. Lulek has recently been elected a director and vice president of manufacturing and research for Grace Chemical Co., New York. Until recently Dr. Lulek was a director and vice president of the Heyden Chemical Corp., and a director and vice president of St. Maurice Chemical Ltd., Montreal.

Clinton W. Adams, Jr., formerly senior technical man, tire development group, tire division, The B. F. Goodrich Co., Akron, Ohio, is now technical representative of International B. F. Goodrich Co. to N. V. Nederlandsch - Amerikaansche Autobandenfabriek "Vredestein," an affiliated tire company located in Enschede, The Netherlands. The duration of this assignment will be for a minimum of three years.

The appointment of **Raymond W. McNamee** as manager of research administration of Union Carbide and Carbon Corp. was recently announced. In this capacity he will help co-ordinate the research activities of all the corporation laboratories where basic research and development is being done on alloys, chemicals, gases, carbons, and plastics. Dr. McNamee joined the corporation's chemical research organization at So. Charleston, W. Va., in 1933, and, since 1950, has been superintendent of the research and development department of Carbide and Carbon Chemicals Co., a division of Union Carbide.

(More About People on page 110)

CLASSIFIED SECTION

SITUATIONS OPEN

SALES ENGINEER

For design and sale of chemical process equipment. Requires college technical training and willingness to travel. This is not a temporary job. First year's employment largely educational and training.

Write, giving information on training and experience, to

C. R. RUNK,

188 Orchard Rd., Newark, Del.

DIRECTOR PRODUCT RESEARCH
OPERATIONS—SERVICES

Chicago manufacturer of cosmetics and toiletries, sound and expanding to provide broad opportunities, is seeking a highly qualified man to direct product evaluation programs under controlled clinic and consumer use conditions and supervise related technical service operations such as physical measurements, packaging studies, and perfume selections. Must have at least ten years' experience in industrial research in one or more of these fields and now be a director or assistant. Must have made technical contributions and be an able administrator and leader. Ph.D. in chemistry preferred. Age 35-45. Salary open, based on qualifications. Your reply will be treated in strict confidence. Box 4-11.

DEVELOPMENT ENGINEER

Some graduate study preferred and six to eight years' experience in petroleum, chemical, power or allied fields of plant design.

Permanent position on the East Coast with an organization known throughout the world for important contributions to the oil and chemical industries for a graduate M.E. or Ch.E. High salary and excellent opportunity to advance as our organization continues to grow. Other employee benefits such as insurance and pension plans are unusually generous.

Please reply giving initial salary requirements and include information on education, background, experience and initial salary desired. Traveling and moving expenses will be paid.

Box 129, Room 1201
230 West 41st St., New York 36, N. Y.

VINYL POLYMER CHEMIST—A well established national manufacturer is expanding its line of products to include polyvinyl acetate emulsions. A chemist or chemical engineer with specific experience in polyvinyl acetate polymerization is needed to take charge of the manufacture and product development of these new products. Excellent opportunity to grow with an expanding organization. Please give details of education, experience and salary desired. Our employees have been informed of this advertisement. Box 1-11.

CHEMICAL AND MECHANICAL ENGINEERS—For production supervision and area engineering in rapidly expanding plastics plant located in Massachusetts. Interesting work with excellent opportunities for good men. Send résumé and salary expected. Replies held in confidence. Box 23-11.

CHEMICAL ENGINEERS FOR MAINTENANCE ENGINEERING and project engineering. Excellent opportunities for aggressive, experienced men who have potential ability to become a department head in a fast growing synthetic resins plant located in New England. Send résumé and salary expected. Replies held in confidence. Box 24-11.

PROCESS DEVELOPMENT

Physical Chemists for process development in Atomic Energy feed materials production and refining.

B.S. and M.S. degrees required. Experience desired but not necessary.

Reply to Box 7-11, stating qualifications and salary requirements.

DIRECTOR BASIC RESEARCH
OPERATIONS—SERVICES

Expanding, well-established Chicago producer of toiletries and cosmetics is seeking an outstanding man to direct fundamental research programs in organic synthesis, analytical chemistry, medical research, microscopy, and instrumentation. Also supervise technical service operations. Must have at least ten years' experience in industrial research in one or more of these fields and now be a director or assistant. Must have made technical contributions and be an able administrator and leader. Ph.D. in chemistry preferred. Age 35-45. Salary open, based on qualifications. Your confidential reply is invited. Box 5-11.

DIRECTORS OF RESEARCH
EMULSIONS—DETERGENTS

Prominent, growing Chicago manufacturer of toiletries and cosmetics is seeking two executives to direct research and product development, one in emulsions and one in detergents. Must now be a director, assistant director, or group leader with at least ten years' related experience in one of these fields, including five years on bench research. Must have administrative and leadership capabilities and have made some technical contributions in one of these areas. Ph.D. in chemistry preferred. Age 35-45. Salary open, commensurate with qualifications. Your confidential reply is invited and respected. Box 6-11.

PROCESS ENGINEER—Ch.E. with six to eight years' experience in process design and development in chemical, petroleum or petrochemical fields. Should have a background in technical services and customer contact. Will work closely with operating division of internationally known engineering organization engaged in the design and development of oil refineries and chemical plants. Excellent salary and opportunity for the right man to assume increasing responsibility. Benefits include executive insurance, unusually liberal pension plans and vacation policy. Traveling and moving expenses paid. Please submit complete details of education, background, experience, past salaries and initial salary requirements. Our personnel have been advised of this opening and complete privacy is assured. Box 3-11.

SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL ENGINEER—PRODUCTION MANAGEMENT—Age 36. M.Ch.E. Twelve years' experience includes resident manager of alcohol plant; chief engineer of eight plant organization; assistant to vice president in charge of production. Seeking responsible position in production, management or plant engineering. Box 2-11.

CHEMICAL ENGINEER—31. Five years petroleum refining, one year process design development of petrochemical and chemical plants. Desire supervisory position in production or technical sales in Eastern United States. Box 8-11.

CHEMICAL ENGINEER—Short-haired Ph.D. Five years teaching. Tired of academic ivory tower. Desire development, industrial research. Licensed P.E. with intensive consulting experience in mass transfer. Imaginative and capable. Age 32, family, veteran. Top references. Box 9-11.

CHEMICAL ENGINEER—B.S., Minnesota. Some graduate work. Over four years' experience in pilot plant process design and development. Married, veteran. Age 27. Desire similar responsible position with progressive organization. Location immaterial. Box 10-11.

CHEMICAL ENGINEER-CHEMIST—Age 30. Graduate business training. Desire administrative position in company headquarters. Interested in economics and other aspects of plant operation, distribution, marketing, and purchasing operations. Willing to assist major executive. Box 11-11.

CHEMICAL ENGINEER—B.S. 1948. Age 25. Two years' experience process design and estimating. Two years engineering officer in U. S. Navy. Employed as production supervisor in small plant dealing with inks and colored plastics. Desire work in sales, technical service, or production with larger company. Box 12-11.

SEASONED CHEMICAL ENGINEER—Sixteen years practice, seeks permanent responsible technical supervisory position. Background includes administrative experience in research, development, design, operation and technical service in petroleum, petrochemical and A.E.C. fields. Professional degree, Q-cleared. Age 39, married. Indicate salary range. Box 13-11.

CHEMICAL ENGINEER—M.S.Ch.E., P.E. Age 33, married. Three years pilot plant and process development. One year production supervision. Eight years process and design engineer for equipment manufacturer. Desire responsible position in process development. Box 14-11.

CHEMICAL ENGINEER—B.S.Ch.E. 1942. Desire position with diversified petrochemical producing company. 5½ years' experience with chemical company in plant operation and engineering. 5½ years refinery project supervision with engineering and construction company. Box 15-11.

TOP LEVEL CHEMICAL ENGINEER—Available to help you with your problems in process and economic evaluation. Twelve years of varied engineering experience in chemicals, petroleum refining and gas including three years handling contacts with clients as a staff consultant. Skilled in working with people to get results. Registered professional engineer. Box 16-11.

CHEMICAL ENGINEER—M.S. 1949. Desire position in research and development or pilot plant requiring initiative and ability. Over four years' diversified experience with one employer. Navy electronics training. Age 29, married. Excellent references. Box 17-11.

CHEMICAL ENGINEER—B.S. 1942. Experience in pilot and fine chemical production in U. S. and abroad. Wide knowledge of pharmaceutical development and production. Desire responsible position in small chemical or pharmaceutical firm. Salary secondary to responsibility and opportunity. Box 18-11.

GAS ENGINEER—Six years' experience with major oil company. Process design, project evaluation and negotiation of natural gas purchase and sales contracts. M.S.Ch.E. Registered professional engineer. Will accept suitable position in same or related field. Box 19-11.

VERSATILE CHEMICAL ENGINEER—Registered in Mass. Six years in plant and equipment design and project engineering, including economic evaluations, on organic chemical and petroleum plants. Four years research and development on pilot plant scale. Box 20-11.

CHEMICAL ENGINEER—Ph.D., P. E. Eight years' experience in petroleum, petrochemical, electrochemical industries including process and mechanical design, process development, economic evaluation, plant operation. Patents, publications. Age 36. Desire responsible position. Eastern area preferred. Box 21-11.

CHEMICAL ENGINEER—Registered P. E. Age 44, married. Experienced in production administration, process and plant design and pilot plant research and development. Pharmaceuticals, plastics, fine and heavy chemicals. Now employed N. Y. metropolitan area but would relocate. Box 22-11.

CHEMICAL ENGINEER—Nine years petroleum refinery process design, operations, and project handling. Good organizer and administrator; handle complete projects. Married, family. Box 25-11.

CHEMICAL ENGINEER—B.Ch.E. 1950. Experience includes mechanical-chemical product development, production management and control. Familiar with government contract procedures. Married, family, age 27. Box 26-11.

REGISTERED CHEMICAL ENGINEER—Twenty-five years' experience spread between three first line concerns in cereal food processing, paint formulation, and metal processing in automotive industry, interested in new connection. Welcomes prearrangement for interview at St. Louis meeting. Box 27-11.

DIRECTIONS FOR USE OF CLASSIFIED SECTION

Advertisements in the Classified Section of Chemical Engineering Progress are payable in advance at 15c a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. More than one insertion to members will be made at half rates. In using the Classified Section of Chemical Engineering Progress it is agreed by prospective employers and employees that all communications will be acknowledged, and the service is made available on that condition. Boxed advertisements are available at $15 a column inch. Size of type may be specified by advertiser. In answering advertisements all box numbers should be addressed care of Chemical Engineering Progress, Classified Section, 120 East 41st Street, New York 17, N. Y. Telephone ORegon 9-1560. Advertisements for this section should be in the editorial offices the 15th of the month preceding the issue.

Harold C. Ries has recently received the appointment of associate professor of chemical engineering, Tufts College, Medford, Mass. He received his B.S. degree in 1942 from Drexel Institute of Technology and was a research fellow at the University of Delaware, Newark, Del.

George F. Klein, Jr., formerly chief engineer, Spencer Chemical Co., has resigned to accept a position in the same capacity with Mechanical Design, Inc., an affiliate of Refinery Engineering Co., Tulsa, Okla.

R. J. Foster, formerly head of the chemical engineering department of the General Mills Research Laboratories, Minneapolis, is now plant superintendent at General Mills, Inc., Kankakee, Ill.

A. M. Gavin is now associated with Armour and Co., Chicago, Ill., in the refinery production control department. He was formerly manager in the solvent extraction plant, American Rice Growers, Houston, Tex.

James A. Luker, formerly professor of chemical engineering at the University of Mississippi, is now associate professor of chemical engineering at Syracuse University.

S. Jack Rini, formerly head of fats and oils section, Kraft Foods Co., Glenview, Ill., is now director of research of The HumKo Co., Memphis, Tenn.

Richard E. Cocks, formerly with Panelyte division, St. Regis Paper Co., Kalamazoo, Mich., is now assistant plant superintendent, plant food division, with Farm Bureau Services, Inc.

Donald R. Guthrie, formerly executive engineer in charge of engineering research, was recently named assistant general manufacturing manager of the coated abrasives and related products division of Minnesota Mining & Manufacturing Co.

W. Kenneth Davis has been promoted from associate professor to professor of engineering, Univ. of California, Los Angeles. He is on leave-of-absence from the University and is manager, research division, California Research and Development Co.

A. J. Gnesin is now with Davison Chemical Corp., Baltimore, Md. He was previously chemical engineer in the research department, Standard Oil Co. (Ind.), Whiting.

Necrology

Chemical Engineering Progress recently heard of the death of Theodore V. Fowler, at one time affiliated with the Buffalo Works of the General Chemical Co. He received a B.S. from M.I.T. in 1903.

INDEX OF ADVERTISERS

Advertising Offices

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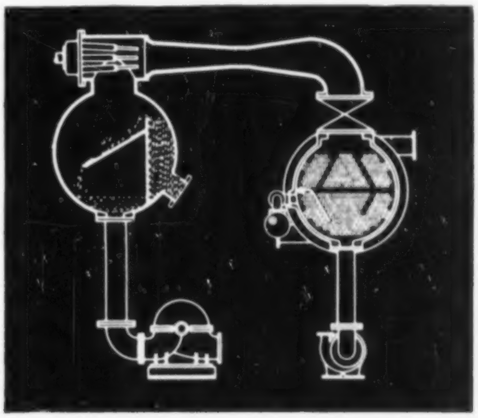
Chicago 4—Richard R. Quinn, Dist. Mgr., 20 E. Jackson Blvd., Room 800, Webster 9-2225.

Cleveland 15—Douglas H. Boynton, Dist. Mgr., 1836 Euclid Ave., Superior 1-3315.

Pasadena 1—Richard P. McKey, Dist. Mgr., 465 East Union St., Ryan 1-8779.



THE PRESIDENT SAYS

One of the rewards of your President is an opportunity to meet many members of the Institute—not as many as I should like and not always under the best conditions for getting acquainted—but it is pleasant, nevertheless. Sometimes "to meet" means just standing before a large group of members with not even a chance to shake hands afterwards. Even this is enough to convey certain impressions to a normally perceptive person. Now, as never before, I am conscious of the solid worth of our membership, the extraordinarily high caliber of the men who band together to carry out the objectives of A.I.Ch.E. This should not be surprising, I suppose, if we consider the processes of selection that are at work.

I have heard it said that only about one person in six is intellectually capable of absorbing professional training. From this small group must come all the professionals—the engineers, the chemists, the physicists, the lawyers, the physicians, the biologists, the teachers and all the rest. Of this group those who become members of A.I.Ch.E. have selected themselves, in a sense, because they have demonstrated a desire to do something concrete to advance our profession. Furthermore, our constitutional requirements for membership comprise the next process of selection and guarantee high standards. The cumulative effect of these successive classification operations is to collect in our membership a large fraction of the most able and most successful people working at the professional level and, particularly, in our profession. Of these, the ones I encounter most are those who voluntarily and actively participate in the Institute's work and programs and this is the final selective process which leads me to the impression of our membership as I see it.

It is little wonder, then, that I get the feeling of a gigantic, compressed, coiled spring. I detect an enormous, pent-up energy which is capable of accomplishing big things if only leadership is supplied. It seems to me that in the normal course of events very little leadership is supplied in many professional societies. Perhaps this is because professional people are usually busy people and can spare only relatively small bursts of effort and time apart from their professional duties. Perhaps, also, professional people feel that they must carry the responsibility for society work and not delegate responsibility and authority to paid employees. Even when paid employees are given a pretty free hand, there are strong influences which tend to put society programs in a rut and the paid employees are likely to assume the attitude of a conductor rather than a leader. The most promising project I can think of for A.I.Ch.E. is one aimed at solving this problem which is fundamentally one of management. How can we manage the controlled release of the potential energy of our membership in order to advance the objectives of A.I.Ch.E.?

I hasten to say that I do not have a trick solution. I have learned some things this year that bear on the question, though, and I have shared some of my thoughts with you and I hope to share more. First, I have learned that there are many, many things to be done to help our members and our profession which can done be better, or perhaps only, through group effort. Second, I have learned that we can hope to accomplish enough to justify our existence and our expenditures only by developing a definite program of worth-while accomplishments embodying both long-range and short-range features. It is not enough to grease the axle that squeaks the loudest at the moment or take off on some tangent because of some whimsical circumstance. Third, I have learned that, somehow, continuity and stability of principles, policy, and programs must be insured. Progress will be slow and halting unless this problem is solved. Furthermore, it is evident that our society like any other, must be protected against the sort of "stable continuity" which results from perpetuation of administration by electoral manipulation of an undesirable kind. Our administration and management, our principles, policies and programs, must reflect the will of our membership.

Fourth, I have learned that the old, familiar committee system can be effective only in some instances and that other methods are workable, which readily produce tremendously better results. For example, I have pointed out the speed and power of the scheme under which an *ad hoc* committee is set to work on a study, the committee consisting of several able men who normally see each other every day. I have learned that societies allow tradition and prejudice to dictate methods which are inherently inept, no matter how "fair and unbiased" they may be. Spreading committee appointments geographically, for example, may lend an air of fairness and impartiality and at the same time make some kinds of committees completely impractical and worthless. Thus, I have learned in still another instance that by "trying to please everybody" one may wind up by pleasing nobody and accomplishing nothing.

Fifth, I have learned that A.I.Ch.E., for one, is not employing the potential energy of its membership nearly as effectively as it should. As a matter of fact it is my personal belief that only a tiny part of our mass strength and ability is in use.

Finally, I have learned that the kind and quality of leadership needed to employ something like the real capacity of our membership to accomplish the worthy objectives that we might undertake is far beyond my ability, at least so long as I must also carry on a busy occupation that is my means of livelihood. I think this is true of any man, even our next President. Consequently, I have learned that the challenge to solve this problem will probably call for new techniques employing initiative on the part of the paid staff with creative imagination being furnished also by Institute members, particularly Council. Such a setup likely would make the President's duties more like those of a Chairman of the Board, auditing and ratifying the actions of paid staff.

Properly organized we can employ the strength and ability of fifty Sections and thousands of individuals. The power is there, and I am convinced that we are learning fast how to use it.

W. T. Nichols